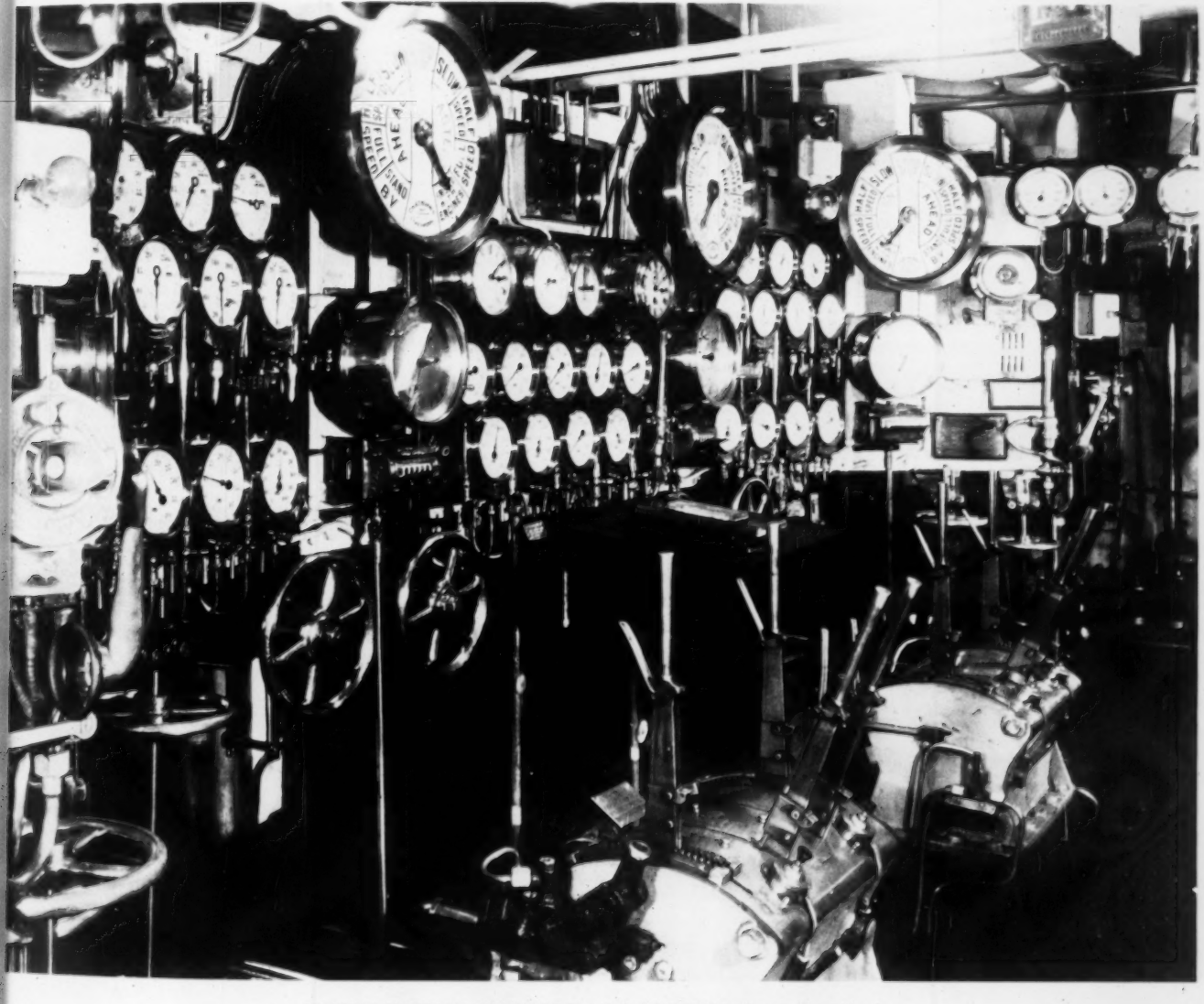
East Engin.
Library

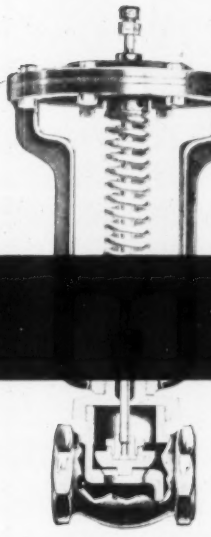
INSTRUMENTS

THE MAGAZINE OF MEASUREMENT AND CONTROL

VOLUME 5 APRIL, 1932 NUMBER 4



STARTING PLATFORM, ENGINE ROOM, S. S. AQUITANIA *(Courtesy Cunard Line)*



For S-m-o-o-t-h-e-r Control

● Living up to its name, the Tycos Evenaction Valve is giving unprecedented satisfaction wherever installed. In many cases it has enabled close control that was impossible with ordinary valves.

● This exceptional performance has been brought about by features in design which have reduced friction to a minimum and given free movement of the valve stem in direct proportion to the air pressure, making "even action" possible.

● Have you a temperature or pressure control job that requires unusual sensitivity? Perhaps you need throttling action that ordinary valves can't give. Write for Tycos Catalog 4 on air-operated regulators with Tycos Evenaction Valves.

Try these

ILLIUM

Thermocouple

Tubes . . .

All advantages combined in one material

. . they Withstand

IMPACT—making them preferable to porcelains. Tensile strength 60,000 lbs. per square inch.

WEAR, ABRASION—chief drawback to lead. ILLIUM'S Brinnell hardness, 170-200.

HEAT—making them preferable to lead or molded plastics. Melting point 1300° C.

CORROSIVE GASES—(particularly oxides of nitrogen and sulfur) hence are better than tubes of steel or iron. So dense and chemically inert is ILLIUM that it's used for oxygen bombs.

MIXED CORROSIVES—in solution, acid or alkaline—from leakage or condensation of moist gases—conditions frequently encountered in plant scale operation. It is at this point of failure for many materials that ILLIUM shows to best advantage.

ILLIUM Thermocouple tubes are available in all standard dimensions—or special sizes can be supplied to your specifications on short notice. Inexpensive either way. Furthermore, first cost is usually the last, as ILLIUM Thermocouples seldom, if ever, need be replaced. Sample lengths for testing sent on request. And may we quote on your requirements?

**For complete information on ILLIUM and its applications in various corrosion resistant services, send for new illustrated bulletin.*

BURGESS-PARR COMPANY

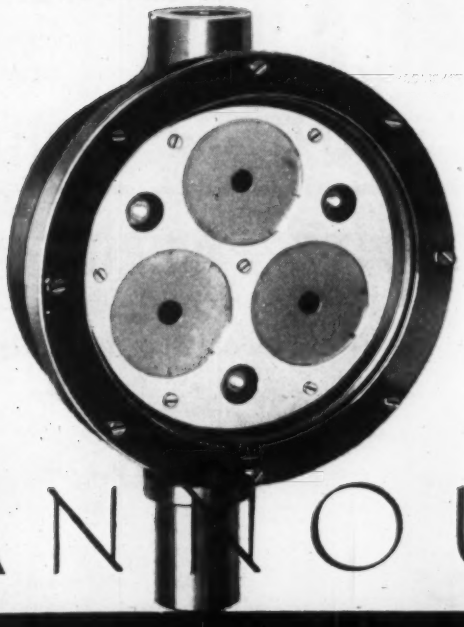
DIVISION OF C. F. BURGESS LABORATORIES INC.

MOLINE, ILLINOIS

Once upon a time a certain man became very sick. On his way to the hospital he canceled his insurance policy. Short-sighted? Yes, but the same thing is being done by some large business concerns. One of their first steps in retrenchment was to cut down advertising. Some companies failed to provide any advertising appropriation. In a very real sense they canceled their insurance of business for the next period of good times.

INSTRUMENTS is published on the fifteenth of each month.
The advertising forms close on the fifth of the same month.

INSTRUMENTS PUBLISHING COMPANY
3619 Forbes Street **Pittsburgh, Penna.**



FOR AUTOMATIC CONTROL OF

STREET LIGHTS · SIGN LIGHTS · AIRWAY BEACONS AND AIRPORT LIGHTING · LIGHT HOUSES · SCHOOL AND CLASS ROOM LIGHTING · STATION LIGHTING ON TRANSPORTATION SYSTEMS · FLOOD LIGHTING IN RAILROAD YARDS · FLOOD LIGHTING OF BUILDINGS

•

LIGHT COLLECTOR—contains Weston Photronic Cells. Mounts indoors . . . or out-of-doors facing north sky. May be located remote from relay cabinet.

ANNOUNCING

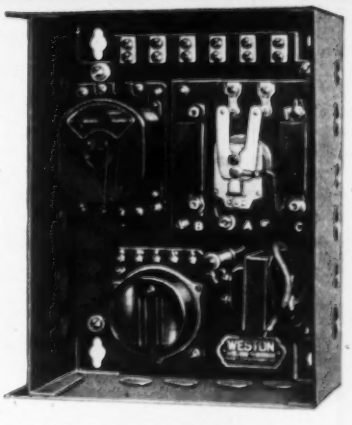
The WESTON *PHOTRONIC* ILLUMINATION-CONTROL *RELAY*

• Now, with the new Weston Photronic Illumination-Control Relay, Model 609, automatic illumination control by light sensitive cells is made practical—simple, trouble-free, easy to install, no maintenance, no readjustments.

• Shipped complete, ready to put to work—Model 609 consists of only two units:—Light Collector and Relay Cabinet. It controls circuits up to 3,000 watts at 110 volts . . . operates on all commercial frequencies, A. C. and down to 6 volts, D. C.

• Model 609's outstanding features together with low cost command the attention of everyone who designs, builds, supplies or maintains illumination.

Descriptive literature gladly sent on request



•

RELAY CABINET — contains relays for controlling circuits up to 3,000 watts at 110 volts. Operates on all commercial frequencies, A. C. and down to 6 volts D.C. Located where desired to simplify installation.

OUTSTANDING FEATURES

NO REPLACEMENTS—using Photronic Cells with unlimited life—maintenance is minimized, amplification eliminated.

UNAFFECTED BY LINE VOLTAGE VARIATIONS—Photronic Cells transform light energy directly into electrical energy—high current output. No auxiliary power needed to actuate sensitive relay.

NO READJUSTMENTS—shipped ready to install and operate.

CELL UNIT REMOTE FROM RELAYS—increased flexibility, ease and low cost of installation.

EASY TO INSTALL—mount units . . . connect with pair of ordinary leads . . . connect power source to Relay Cabinet to complete installation.

CONTROLS 3,000 WATTS AT 110 VOLTS—operates on all commercial frequencies, A. C. and down to 6 volts D. C.

LIGHTNING FLASHES—and quickly passing shadows and smoke do not actuate the relay.

LOW INITIAL COST—and practically free from all maintenance.

WESTON

ELECTRICAL INSTRUMENT CORPORATION

591 FRELINGHUYSEN AVENUE · · · · · NEW[illegible] 1.

INSTRUMENTS

THE MAGAZINE of MEASUREMENT and CONTROL

RICHARD RIMBACH
Managing Editor
Engineering Editors
M. F. BEHAR
H. OLKEN

◈

Editorial Advisory Board
G. BERNDT
Technische Hochschule. Dresden, Germany
W. G. BROMBACHER
United States Bureau of Standards
A. V. De FOREST
American Chain Company
K. J. de JUHASZ
Pennsylvania State College
PAUL B. FINDLEY
Bell Telephone Laboratories
JOHN L. HAUGHTON
National Physical Laboratory, England
H. L. HAZELTINE
Sterling Varnish Company
C. A. HEILAND
Colorado School of Mines
HANS VON JUEPTNER
University of Vienna, Austria
GEORGE KEINATH
EDITOR, Archiv fuer Technisches Messen
FRIEDRICH KOERBER
Kaiser-Wilhelm-Institut fuer Eisenforschung, Germany
E. S. LINCOLN
Consulting Electrical Engineer
RICHARD R. MOORE
Wright Aeronautical Corporation
ALLEN LESLIE NORBURY
British Cast Iron Research Association
FOSTER D. SNELL
Consulting Chemist
THOMAS SPOONER
Westinghouse Electrical and Manufacturing Company
FRANCIS M. TURNER
EDITOR, Chemical Catalog Company
JOSEPH LYNCH, S. J.
Seismic Station, Fordham University
S. R. WILLIAMS
Amherst College
W. R. WORK
Carnegie Institute of Technology

◈

Advertising Offices:
Main Office, 3619 Forbes St., Pittsburgh.
Boston, 86 St. Botolph Street.
New York, 419 Fourth Avenue.
Rochester, 821 Powers Building.
Los Angeles, 1206 Maple Street.
San Francisco, 1045 Sansome Street.
Portland, 311 Pine Street.

◈

Published Monthly on the 15th by
The Instruments Publishing Company
3619 Forbes Street, Pittsburgh, Pa.
JOSEPH J. VIGNEAU, President
RICHARD RIMBACH, Vice-Pres.-Treas.

◈

Annual Subscription, $2.00. Copyright, 1932, by The Instruments Publishing Company.
Entered as second-class matter January 26, 1932, at the post office at Pittsburgh, Pa., under the Act of March 3, 1879.

CONTENTS—APRIL, 1932

Determining Range of Helical Bourdon Springs 85
Charles Susa

Visualizing Electrical Meter Protection . . . 87
E. V. Sundt

Aging and Elastic Hysteresis in Instrument Springs 89
Paul MacGahan & Robert W. Carson

Telemetering (a correction) 91

Flow Measurement and Control 93
M. F. Behar

Table of Contents A4
Editorial Comment A9
Instruments Abstracts A11
Book Shelf 100
Instrument's Index A17
Advertisers' Index A22
Manufacturers' Literature 95

New Instruments

Rubber Abrasive Resistance Tester 107
Steel Writer 107
Multi-Range Voltmeter and Milliammeter 107
Printers' Moisture Indicator 107
A New Self-Acting Temperature Regulator 108
Vacuum Contact Midget Relay 109
Enameled Variable Resistors 108
Push-Button Stations for Heavy-Duty Service 109
A New Tape-Rule 108
Water and Dust Tight A.C. Manual Starter 109
New Shielded Ratio Box For Impedance Bridges 109
New Vacuum Tube 109
Fractional H.P. Motor 109
Megohm Decade Resistance Box 110
Portable Recording Pyrometer 110
New Automatic Combustion Indicator 110

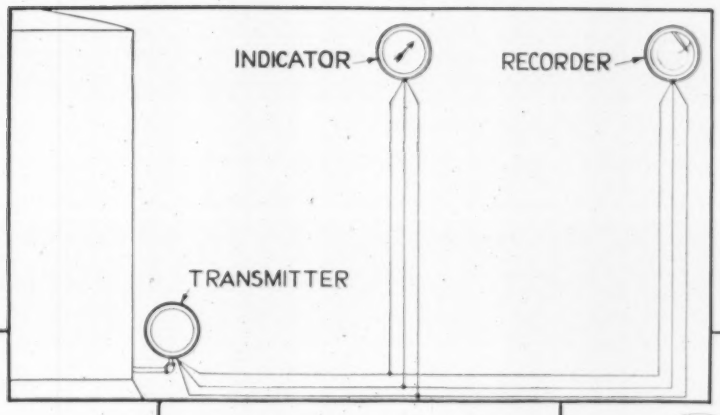


Fig. 1 — Manometer Type Transmitter Arranged to Transmit Liquid Level.

Fig. 2—Float Type Motion Transmitter Arranged to Transmit Liquid Level.

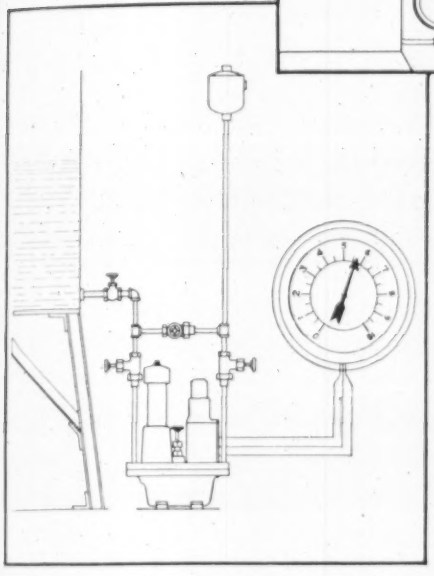
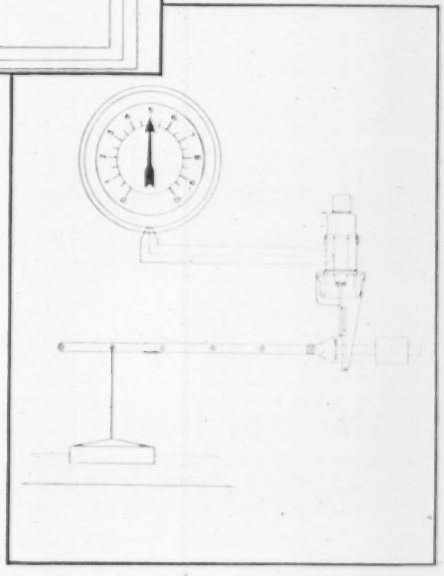


Fig. 3 — Helix Type Transmitter Arranged to Transmit Liquid Level.



BROWN REMOTE TYPE

Liquid Level Gauges

Made in Three General Types

MANOMETER TYPE—Operates with manometer type transmitter. Changes in hydrostatic pressure, produced by changes in the liquid level being measured, cause corresponding fluctuations in the level of a body of mercury carrying a float and supporting an armature in an inductance coil. The motion of this armature is duplicated in the receiving instrument, and is converted into accurate indications or record of the changes in liquid level affecting the transmitter. Illustrated by Fig. 1.

FLOAT TYPE—Operates by means of float actuating Brown motion transmitter. Changes in the float level alter, through a suitable reduction gear, the position of an armature within an inductance coil inside the motion transmitter case. The motion of this armature is duplicated in the receiving instrument, and is converted into accurate indications or record of the changes in liquid level affecting the transmitter. See Figure 2.

HELIX TYPE—Operates with helix type transmitter. Changes in hydrostatic pressure, produced by changes in the liquid level being measured, cause expansion or contraction of a specially designed helix actuating an armature within an inductance coil inside the transmitter case. The motion of the armature is duplicated in the receiving instrument. See Figure 3.

For full details get Brown Remote Type Catalog No. 7501.

THE BROWN INSTRUMENT COMPANY

4482 WAYNE AVENUE PHILADELPHIA, PA.

Branches in 22 Principal Cities

Brown Recording Pressure Gauges

To Measure is to Economize

Eagerly Expected . . Just Off the Press

and Now if You Are—

—AN ENGINEER,

—AN INDUSTRIAL EXECUTIVE,

—A RESEARCH WORKER,

—AN ENGINEERING TEACHER OR STUDENT,

—IN CHARGE OF A PROCESS, OR

—IN THE INSTRUMENT INDUSTRY ITSELF,

You Will Fill Out This Coupon

and Order Your Copy of

FUNDAMENTALS *of* INSTRUMENTATION

By M. F. BEHAR

NEVER was the importance of measurement and control so keenly felt by industry as in these times. This book opens the door to countless ideas of incalculable value. It is not a mere collection of "kinks" but a basic text, every line of which will be read profitably. The benefits of measurement and control never come of their own accord, but only when instruments are intelligently applied. This book takes you by the hand and leads you into the newest branch of engineering—the newest field of scientific management—Instrumentation.

Not only does it crystallize and summarize the elements of the science of measurement and the art of control, but it lays down for the first time an impressive amount of new data never published before. The author has also induced other prominent instrumentation engineers to explain in detail "how they do it." Altogether, this is more than a book: it is a tool!

BRIEF OUTLINE OF CONTENTS

Industrial Instruments — General: Their Functions, Classes, etc.

Properties and Characteristics of Industrial Measuring Instruments—Accuracy, Sensitivity, Behavior, etc., with a special section on Recorders.

Performance of Automatic Controllers—the first basic treatment of this important subject.

The Plant Instrument Department—By specialists in this branch.

Instruments Publishing Company Date.....
3619 Forbes Street, Pittsburgh, Pa.

Enter my order for a copy of "Fundamentals of Instrumentation" by M. F. Béhar, at two dollars ($2.00) postpaid.

Name.....

Address.....

More Than a Book —a Tool!

The various Ward Leonard Products are described in numerous bulletins. Please indicate on the coupon below the class of products in which you are interested.

Ward Leonard Products

Resistors
Field Rheostats
Magnetic Relays
Speed Regulators
Motor Starters
Dimmers
Projection Rheostats
Laboratory Rheostats
Battery Charging Rheostats
Automatic Voltage Regulators

If you want *Pigtails* . . .

we'll furnish them with *pigtails*

YOU can have any type of terminals you want . . . any load rating . . . any resistance value . . . any dimensions . . . for these are all variable elements of Ward Leonard Vitrohm (vitreous enamelled) Resistor Units, changed to intimately suit your particular requirements for each job.

But certain other elements are constant. You *cannot* ask us to vary dependability and long life.

In all Ward Leonard Vitrohm Resistors, wire, base and Vitrohm are carefully balanced in regards to coefficient of thermal expansion. Consequently no internal stresses or strains are set up because of temperature changes. The resistance wires are protected by being cast and fired in Vitrohm. Th remarkable heat-conducting, ac and moisture resisting, glass-l enamel is manufactured witl the Ward Leonard Plant. It kee the temperature of the wire at times well within safe limits. A terminal joints are silve to insure perfect con

Your job is is treat

WARD LEONARD *RESISTORS*

Instrumentation

● Process uniformity and the desire for continuous production at high rates and of high quality have led to a revolution in the use of instruments. The physical variables of a process:—**Temperature, Pressure, Flow, Liquid-Level** and **Humidity**—must be controlled to achieve Process Uniformity.

● The application and use of instruments to achieve a **Result** such as this is termed "Instrumentation." It is a complete job and is as much engineering as instruments.

● Foxboro has the Engineers, the Experience and the Instruments, necessary to solve every problem of Instrument control. Together with your own engineers they will be glad to make an instrument survey of your present or proposed plants and recommend the necessary Instrumentation.

● Whether you want complete Instrumentation or a single instrument you can get it from Foxboro. Information on our instruments or service will be sent promptly. Write today.

THE FOXBORO COMPANY

Neponset Ave., Foxboro, Mass., U. S. A.

New York, Philadelphia, Detroit, Pittsburgh, Cleveland, Rochester, N. Y., Atlanta, Los Angeles, Dallas, Tulsa, Portland, Ore., San Francisco, Salt Lake City

Canada—Peacock Brothers, Ltd., Montreal. Australia—Alfred Snashall, Ltd., Sydney & Melbourne. England—Walker Croswelfer & Co., London. P. I.—The Edw. J. Nell Co., Ltd., Manila

EDITORIAL COMMENT

In This Issue

◆ Pressure gage springs of the Bourdon type are better understood and more appreciated after acquaintance with Mr. Susa's treatment of **Bourdon Springs.**

◆ Meter springs may be delicate, and yet be all that the instrument user desires. Messrs. MacGahan and Carson write of the studies which led to the realization of improved **Instrument Springs.**

◆ Considerable light is shed on meter protection, and incidentally on the industrial potentialities of rapid photography in the article **"Visualizing Meter Protection."**

◆ And again—an installment of "The Manual of Instrumentation," on **Primary Elements of Flow Meters** in the "head" class. In addition to the products well known by virtue of recognition as standard by engineering committees, Mr. Behar brings to the reader's attention some less-known but ingenious commercial devices that may meet many a reader's needs in flow measurement.

◆ Following **Instruments Abstracts** will keep you posted on the "current events" in your field of technical interest.

◆ ◆ ◆

The Front Cover

◆ Gives a close-up of the instruments that control a famous "ocean-greyhound"—the engine room controls in S. S. Aquitania.

(Photo by Courtesy of Cunard Steamship Co., Ltd.)

Instrumentation and Industries

TO MOST plant operators an instrument for a long time signified "a doo-dad with a scale and a pointer" and "used to check this or that"—furnace temperature, steam flow, or whatever was a critical factor in the process at his plant. By this day and age instruments are known to be more than doo-dads, and their function is understood to be more than a matter of checking. In fact, it is becoming recognized that there is such a thing as *instrumentation*, that it is instrumentation which secures the control of product or process, and that it leads to more and better production at lower cost.

But no sooner do these facts become generally recognized, than it is time for realization of this greater fact—the fact that instrumentation brings in its wake transformation of old products or old industries, and creation of new ones.

For industries have ceased to grow like Topsy—haphazardly and at random. Instead, progress is all in the direction of first studying exactly what is wanted in the way of a product—working up a complete set of product specifications, so to speak; then follows development of a process for fabricating a product to the required specifications. And in studying a product, or in developing a process, the basic tools used are instruments.

As a particularly striking illustration of this consider the field of chemistry alone. Back in December, 1930, it was already an established fact that "Rule of thumb is on the way out. Automatic recording and control instruments have been widely accepted as the 'Sine qua non' of successful operation."* But things have already gone far beyond this.

In the story of Duco we have an excellent illustration. The automobile industry was clamoring for a new paint product. The specifications it had to meet were clear and precise. It must provide a finish for automobiles that: a) could take a high polish; b) would remain uncracked after long exposure to the weather; and finally c) could be applied so quickly and easily that automobile production would not be tied up for the weeks and days then required for the painting job.

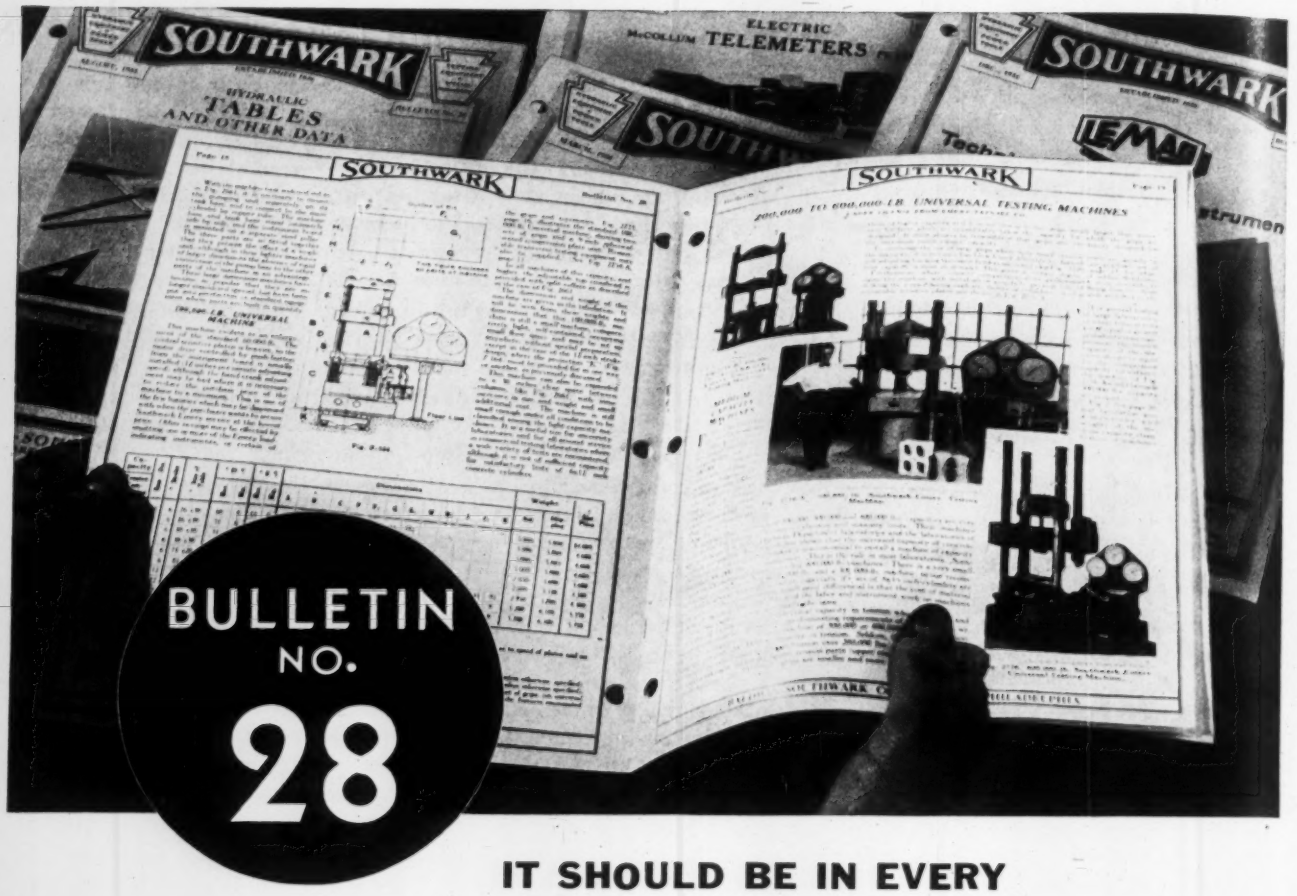
After years of study the new product meeting these specifications is produced in the laboratory. Then begins the development of a *new* industry. A process must be developed for large scale production of the new product. First production on a 100-gallon scale is worked out. Finally, after much toil and expense, the process is made to work on the 10,000 gallon scale.

Microscopes, colorimeters, pH indicators, temperature and pressure devices both indicating and recording—optical instruments, electrical instruments, and almost every other kind of instrument was called into play. Thanks to their aid in the service of the chemist, a new product was made, a new process developed, a new chemical industry created, and the automobile industry transformed.

What has occurred in the chemical industry is occurring likewise in the other industries: foods, metals, textiles, rubber, paper, gas, ceramics, etc. One has but to look a few years back in an industry's history to realize that instrumentation—the practice of measuring, testing, controlling—leads to more than better and greater production: it leads to the creation of new products, new processes, and hence new industries.

*H. Burton Lowe (Advertising Manager, *Industrial & Engineering Chemistry*). "What Does the Chemical Man Buy?" *Class & Industrial Marketing*, Dec. 1930.

SOUTHWARK'S NEWEST...



IT SHOULD BE IN EVERY TESTING ENGINEER'S LIBRARY

DESCRIBED—the evolution of hydraulic testing machines down through the years, to the latest, largest universal machine in the world. Detailed—instruments, indicating and recording; the load producing mechanisms; controls; gripping mechanisms; etc. Outlined—modern practice in utilization. A collection of standard and special testing machines and instruments unrivaled in scope and development.

Profusely illustrated, including charts and tables showing capabilities, dimensions, weights. Concisely written as a text book that traces the progress of all that is outstandingly modern in thought, in equipment and in practice.

Typical of Southwark—headquarters for testing equipment for practically every mechanical purpose in engineering, construction, transportation and Industry.

Write for Bulletin No. 28. Sent on request.

BALDWIN - SOUTHWARK CORPORATION
SOUTHWARK DIVISION PHILADELPHIA, PA.

SOUTHWARK

DETERMINING RANGE OF HELICAL BOURDON SPRINGS

By CHARLES SUSA*

MUCH time and material can be saved in manufacturing Bourdon springs of a specific range, by calculating the range of helical springs according to the method explained herewith. The circular motion at the free end of a helical spring is due to the pressure acting within the spring, and changing the cross-sectional shape of it. The spring diameter and circumference are thereby both caused to change, forcing the free end of the spring to travel in a circular path. The helical Bourdon spring is shown in Fig. 1.

The section thickness T of the spring varies proportionally to the pressure. The cross-section of the spring can be compared to a uniformly loaded beam, fixed at both ends. Fig. 2 shows an enlarged cross-sectional view of a helical spring. The formula for an increase in T is

$$y = \frac{W \times l^3}{384 \times E \times I}$$

where W is the total load along length l, E is the modulus of elasticity and I is the moment of inertia.

*Fenn College

In order to verify this equation, a brass helical Bourdon spring was connected to a dead-weight tester. The pressure within the spring was increased by 20 lb. increments during which the thickness T of the coil was measured with a dial indicator. The calculated and actual values of the thickness T were tabulated and compared. The beam formula and the experimental values checked very closely. The average difference between the values was 0.089%, the greater part of the difference being accountable to experimental errors. Fig. 4 is a graph showing the calculated and experimental T values plotted against pressure. Tests on Bourdon springs of different wall thickness checked with the beam formula.

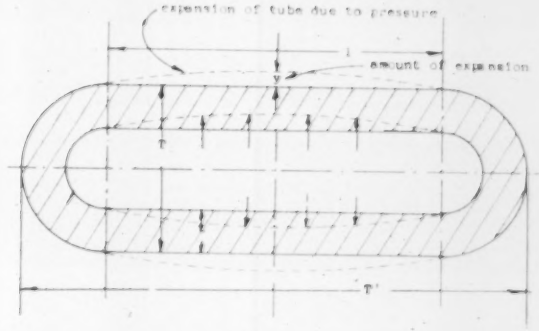


Fig. 2 (at right). Enlarged Cross-Sectional Drawing of Helical Bourdon Spring.

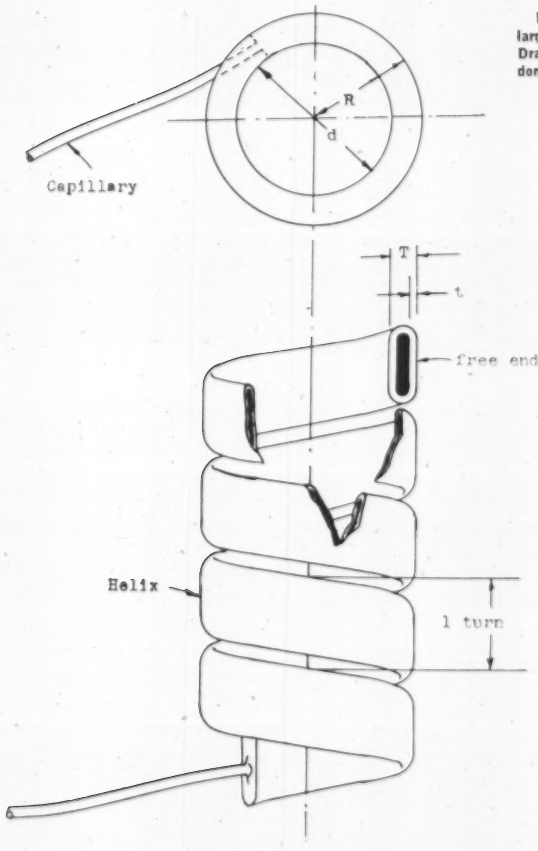


Fig. 1. Helical Bourdon Spring.

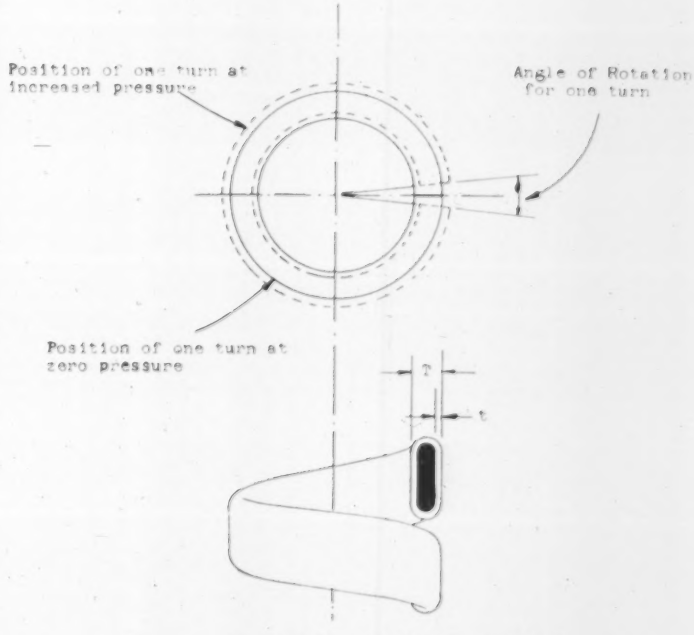


Fig. 3. One Turn of a Helical Bourdon Spring.

As the section thickness T increases with an increase of pressure the diameter d grows greater. The difficulty in calculating the range of a helical spring lies in determining the ratio of diameter increase to the increase of section thickness T. The ratio is not the same for springs of different wall thickness t. It is necessary to find the ratio values experimentally, because it is the simpler and more accurate method. Helical Bourdon springs of different wall thickness were carefully calibrated, and the following data tabulated:

Pressure range	100 lbs./in.^{2}
Degrees motion	27.3
Active turns	12.5
Material	brass
Wall thickness, t	0.017″
Initial section thickness, T	0.056″
Initial diameter, d	1.00″

The above data was taken from the first calibrated spring. All of the calculations and determinations are based on one turn.

The section thickness was calculated from the beam formula and found to be 0.05682 in. at 100 lbs./in.^{2} If at zero pressure the angle of the circumference equals 360°, and the perimeter remains constant, the angle of the perimeter will be less as the pressure increases and with it the circumference. The angle of the constant perimeter at any pressure is equal to 360° minus the angle of rotation of one turn of helical spring. Fig. 3 shows the positions occupied by one turn helical spring, at pressures from zero upward. In the case of a 12.5 turn spring, the free end rotates 27.3° at 100 lbs./in.^{2}; consequently one turn rotated 2.18°. By applying the formula,

$$R = \frac{180s}{3.1416 \times \theta}$$

in which s is the arc or constant perimeter subtending θ degrees, and R is the radius, the formula becomes

$$R = \frac{180\,(d + 2T)}{\theta}$$

when for s is substituted the circumference of one turn at zero pressure, which is equal to $3.1416 \times (d + 2T)$. θ is equal to 360° minus the rotation of one turn. In the case of the example,

$$R = \frac{180\,(1 + 2 \times 0.056)}{360 - 2.184} = 0.55939 \text{ in.}$$

Subtracting the radius at zero pressure from the radius at 100 lbs./in.^{2} pressure, r, the increase in R, can be found.

$$r = 0.55939 \text{ in.} - 0.55600 \text{ in.} = 0.00339 \text{ in.}$$

In the table below are the tabulated values, at the two pressures.

Pressure	Dia.	R	T	y	r
0.0 lbs./in.^{2}	1.1120 in.	0.5560 in.	0.0560 in.	0.0 in.	0.0 in.
100 lbs./in.^{2}	1.1187 in.	0.55939 in.	0.05682 in.	0.000409 in.	0.00339 in.

As the pressure increases within a spring, y grows larger and r increases in direct proportion. Fig. 5 shows the straight line, the result of plotting y against r, the increase in radius. The slope of this straight line varies with wall thickness t and section thickness T. The slope variation is along the curve seen in Fig. 6, where the abscissa is the product of wall thickness t and section thickness T; the ordinate is the slope, or y/r. By plotting these values for Bourdon tubes of different E and l over a variety of wall and section thickness, and connecting the points plotted, the result will in each case be a curve such as seen in Fig. 6.

After setting up the equations and curve, it is quite simple to find the range of any helical Bourdon spring, without the need of mounting a helical spring on a test rack. The range consists of finding the angle that the free end of the spring has been rotated by the pressure within the spring. The first thing to do is to list all the known data of the spring. In order to simplify the use of the formulas and slope curve an actual example will be illustrated.

Pressure, p	475 lbs./in.^{2} (assumed value)
Degrees motion	Unknown
Wall thickness, t	0.027 in.
Material	Brass
Modulus of Elasticity, E	13,400,000 lbs./in.^{2}
Section thickness, T	0.0845 in.
Length of beam, l	0.2599 in.
Diameter	1.0 in.

The following formulas are simplified in order that the above values may be directly substituted.

$$y_p = \frac{p \times l^4 \times 12}{384 \times E \times t^3} \qquad (1)$$

$$\text{Slope} = \frac{y}{r}; \qquad r_p = \frac{y_p}{\text{Slope}} \qquad (2)$$

(Continued on page 88)

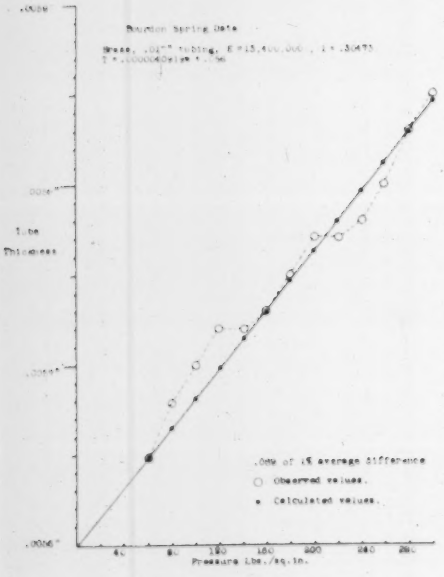


Fig. 4. Relation of Wall Thickness to Pressure.

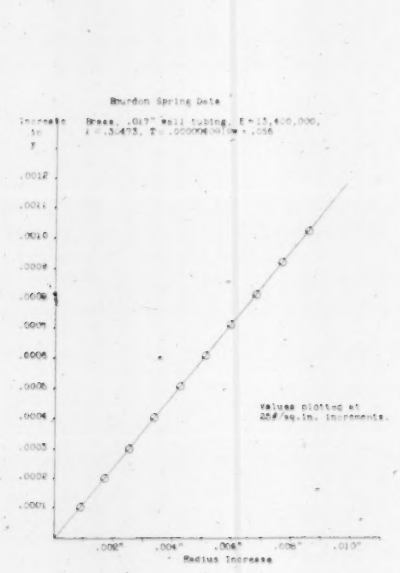


Fig. 5. Values of y Plotted Against Increase in Radius, the Result, a Straight Line.

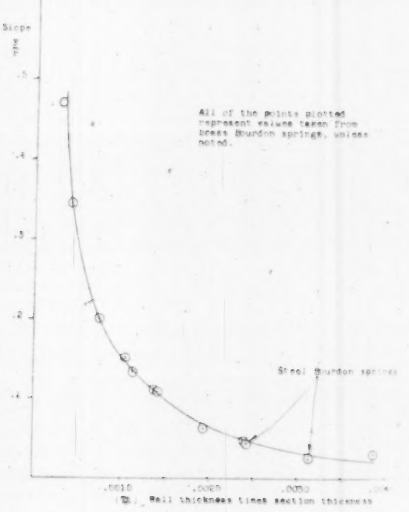


Fig. 6. The Curve Represents the Variable Slope y/r in Bourdon Springs of Different Wall Thickness.

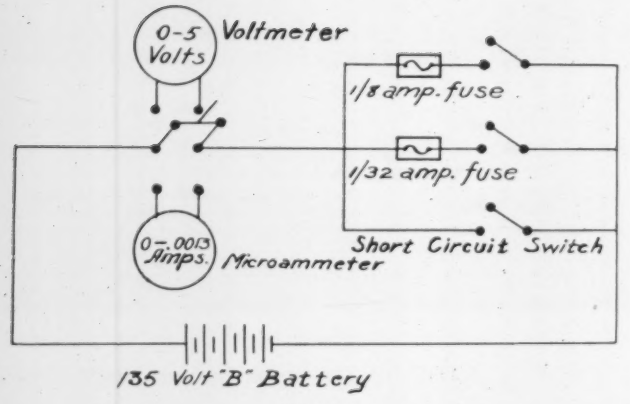
VISUALIZING ELECTRICAL METER PROTECTION

By E. V. SUNDT

ELECTRICAL meters are very liable to be subjected to damaging over-loads either through carelessness or through abusive service conditions. It is therefore of considerable value to know what are the damaging conditions, and how far protective devices go to insure against them.

MANY production or process operations occur at high speed. To study these operations for greater control or increased production, industry will find a very useful tool in motion picture photography. Pictures taken at high speeds catch all the rapid occurences which otherwise escape notice. Also, they provide permanent views that can be studied at leisure to get all the details. How this applies to the study of electrical meter protection is presented below.

Motion Pictures of What Happens When 135 Volts Is Impressed on: A 0-5 volt voltmeter in series with an 1/8 ampere fuse—Series A. A microammeter protected by a 1/32 ampere fuse—Series B. The microammeter with no fuse in leads to meter—Series C. Photos taken at intervals of 1/64 sec. with a Bell & Howell motion picture camera. Photograph in lower right hand corner shows test set up.



Test Circuit

With this idea in mind, the Littlefuse Company made a high speed motion picture study of several instruments being protected by fuses in order to see what actually takes place in the split fraction of a second during which the meter is under a short circuit.

It certainly seems unreasonable that a 30-0-30 galvanometer (22 microamperes per division) could be protected by a fuse rated at 1/32 ampere or 24 times the full scale current value of the instrument. Nevertheless, the protection is real because the action of the fuse is so much quicker than the meter burnout. Meters are not burned out by a current two or three times their rated value—that merely puts them off scale. The most delicate meter will carry up to one-half ampere (except a few of the thermo-couple type) for a few thousandths of a second without injury. Protection is therefore largely a time proposition, and the fuse must open the circuit before the meter needle has had time to make its lightning leap to the right. It is within these few thousandths of a second that the fuse must act in order to be effective.

Pictures A^1 to A^5 are taken of a 0-5 voltmeter, 75 ohms per volt, being protected by an 1/8 ampere fuse. Camera speed was 64 exposures per second and the exposure time 0.0092 second. Battery voltage was 135 applied directly across the meter with the fuse in series. Actual blowing time of the fuse as recorded by the oscillograph tests is between 0.002 and 0.003 second. The needle reached its maximum swing in A^3 and receded uninjured.

Pictures B^1 to B^5 are of the 30-0-30 galvanometer referred to above, protected by a 1/32 ampere instrument fuse. Camera and exposure time are the same as before. Needle swing reached maximum at B^3 and receded uninjured. The actual blowing time of this fuse by oscillograph tests is .001 second. A very short length of time—so short in fact, that the intense short circuit current did not persist long enough to injure the meter.

Pictures C^1 to C^3 tell the fateful story of what happened to the above galvanometer under a direct short circuit without a fuse. It will be seen that the needle covered the entire scale during the exposure time of 0.009 second. After that fast indication it cost about $4.00 to put the meter back into service.

The interesting conclusions from these tests are, then, that meter elements can withstand excessive overloads, if the time of their duration is kept momentary enough. Hence a protective device, such as a fuse, which interrupts the excessive current before its violent kick and rapid heating effect destroy the meter, can insure the meter against damage by even a dead short circuit.

◆ ◆ ◆ ◆ ◆

(Continued from page 86)

$$R_p = r_p + \frac{d}{2} + T_p \qquad (3)$$

$$\theta_p = \frac{180 \times (3.1416 \times [d + 2T_p])}{3.1416 \times R_p} \qquad (4)$$

$$360 - \theta_p = \theta \text{ rotation of one turn.} \qquad (5)$$

In the above formulas all units are to be in inches. The value p in formula (1) was substituted for w and is in lbs./in.^{2} In order to find the amount of rotation at the end of the free end of the Bourdon spring, a pressure must be assumed to be within the spring to cause rotation. In the example used, p was assumed as 475 lbs./in.^{2} Care must be exercised in picking out a pressure for the spring because a large enough pressure must be used so that ample rotation takes place; and too great a pressure is liable to cause spring deformation.

After substituting values in formula (1), y_{475}, that is y for p = 475, was found to be 0.0002415 in. After multiplying t times T_o, the slope of the spring can be found from Fig. 6 to be 0.0635, substituting this value in formula (2) the r_{475} can be calculated. Then in order to find the radius R_{475} the values $r_{475}, \frac{d}{2}$, T_{475} are added, as in formula (3). T_{475} is found by taking T_o and adding to it $2y_{475}$. R_{475} was found to be 0.58900 in., r_{475} was 0.00399 in. By substituting all the known values in equation (4) the angle of rotation can be found, after θ_{475} is subtracted from 360°. The calculated angle of rotation for one turn was found to be 2.96°, or 29.6° for the entire spring of 10 turns.

The spring in this example was then mounted on a test rack, and calibrated. It was found that at 475 lbs./in.^{2} the free end of the helical Bourdon spring moved 27.3°. The difference between the calculated calibration and the actual calibration was 2.3°, an error of 7.8%. After considering the great number of sources for error, the total error of even 10% is quite small.

The main value of the formulas given above is not only that they help to calculate the ranges of helical Bourdon springs, but help to understand the functions of the Bourdon spring. Thus the formulas show that a very strong spring, a spring for very high pressures, can be made in a number of different ways; by decreasing the angle of rotation per unit of pressure; by increasing the modulus of elasticity; by decreasing the value l or increasing section thickness T; by decreasing the number of active turns, or by increasing the wall thickness t. Conversely, by the opposite changes of these quantities, a flexible spring for low pressures will result.

◆ ◆ ◆

ANNOUNCEMENT is made that C. F. Burgess Laboratories, Inc., of 202 East 44th Street, New York City, have taken over the activities of the Burgess Battery Company in the sale of Burgess Radiovisor Bridges (light-sensitive cells), vacuum contacts, vacuum contact relays, micro relays, light control units and other electronic devices, as well as the acoustimeter line of the Burgess-Parr Company. This move is prompted by the desire of the officials of the various Burgess industries to concentrate the sale of all electronic devices in one organization for greater convenience to all concerned.

Aging and Elastic Hysteresis In Instrument Springs*

By PAUL MacGAHAN† & ROBERT W. CARSON†

IN electrical measuring instruments accuracy depends as much on the quality of the control springs as on the design of the torque producing elements. However, judging from the published work on the subject, the design of high quality control springs has not received its proper share of attention.

Unstable effects found in the use of spiral instrument springs arise from a temperature change in the elastic modulus of the spring material, from secular change or aging in service, and from elastic hysteresis, all of which may under certain conditions introduce appreciable errors.

That the industry is well aware of these effects is evidenced by the almost universal use of some form of a zero adjuster on spring controlled instruments. However, to the authors' knowledge no study of the causes of aging or elastic hysteresis of instrument springs has been published.

Manufacture of Instrument Springs

In the usual shop methods of making spiral instrument springs, hard drawn wire of a suitable material such as phosphor bronze is rolled with many passes through the rolls to a hard, thin ribbon. Several lengths of the hard ribbon are wound together around an arbor, and held tightly wound with a close fitting barrel as shown in Fig. 1. The ribbons in the

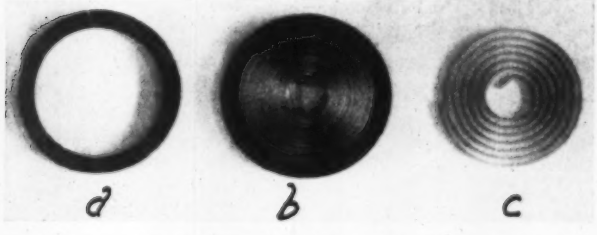


Fig. 1. Forming Spiral Instrument Springs.
(a) Forming barrel.
(b) Barrel filled with spring ribbon ready for heat treatment.
(c) Spiral spring.

filled barrel are then formed into spiral shape by heating the assembly for several minutes at a moderate temperature, in some instances about 300° C. When the ribbons are removed from the barrel they permanently retain an approximation of the spiral shape they assumed when wound in the barrel.

Aging Effects

Spiral springs, unless carefully prepared, are subject to zero shift and simultaneous change in strength during long periods of service. This zero shift which was found to be an uncoiling of the spring, may amount to 5° or 10° of arc, and the spring torque may increase 2 to 5% in the course of several months under severe service conditions. An investigation of these two effects disclosed that they are parallel changes and that the rate of change increases rapidly with an increase in operating temperature. As shown in Fig. 3 the rate of uncoiling at 100° C. is nearly 100,000 times as rapid as the rate at room temperature.

This investigation further disclosed that the forming operation had an important effect on the aging tendency. When lower forming temperatures are used the springs are found to have a greater tendency to age accompanied by a larger normal free diameter. This was believed to be very significant. Recognizing that a larger outside diameter of the spring as formed results from greater internal stresses not relieved by the forming operation, it follows that aging in service is caused by residual stresses. Further investigation developed the fact that aging of the spring in service could be eliminated by a mild heat treatment at a temperature somewhat higher than temperatures usually found in service. As shown in Fig. 3, the uncoiling or relaxation of residual stresses takes place very rapidly at temperatures of 100° to 150° C. After heating at a given temperature for a length of time depending on the temperature used, no further aging was found at any lower temperature.

Elastic Hysteresis Effects

Attempts were made to measure the elastic hysteresis of spring wire and ribbon under conditions similar to those found in service. Many methods were adopted to test the spring ribbon under load, time, and temperature conditions similar to normal service conditions found in instruments electrical methods as well as mechanical and optical, but all had serious limitations. Accurate measurements of elastic hysteresis at small stresses were finally made using a grid glow tube relay to indicate the point of contact between the micrometer and

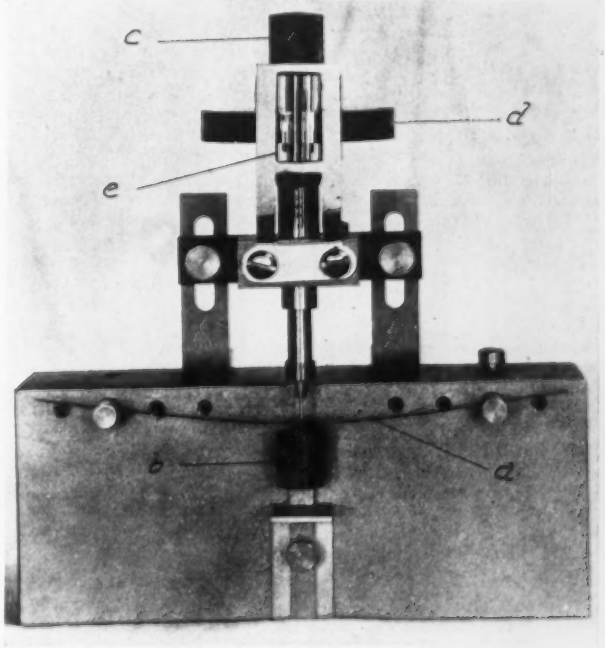


Fig. 2. Grid Glow Micrometer.
(a) Spring ribbon under test.
(b) Load weight.
(c) Micrometer.
(d) Large diameter micrometer barrel.
(e) Magnifier for reading settings.

*Extended abstract of a paper presented at the Winter Convention of the American Institute of Electrical Engineers in New York, January 1932.

†Development Engineer and Meter Engineer, respectively, Westinghouse Electric & Manufacturing Company.

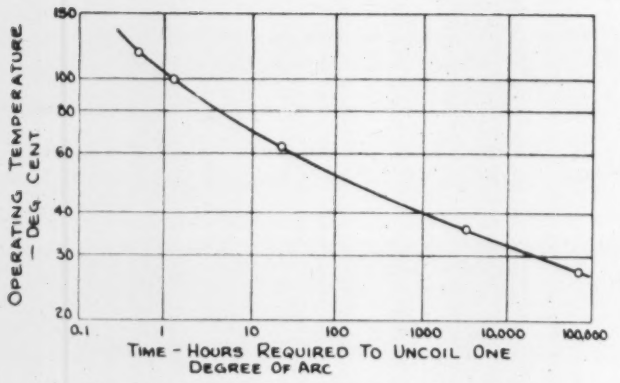


Fig. 3. The Effect of Operating Temperature on the Rate of Uncoiling of Untreated Spiral Springs.

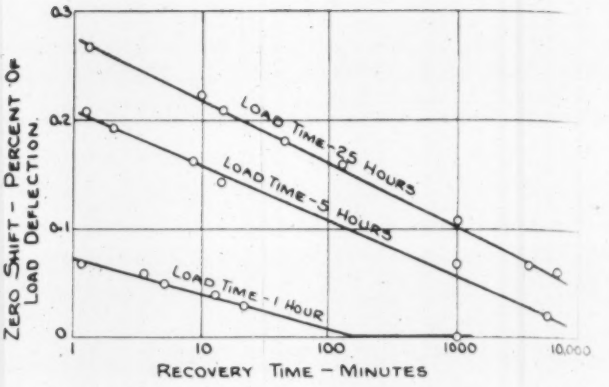


Fig. 4. The Effect of Load Time on the Elastic Recovery of a Spring Ribbon. Phos. bronze ribbon formed flat load strain—0.0008 inch per inch. Tested on the grid glow micrometer.

the ribbon. When it was found that this device was sensitive to smaller displacements than could be read on the micrometer a large diameter barrel viewed through a magnifying lens, as shown in Fig. 2, made it possible to read deflections of the ribbon in ten-thousandths of an inch. Further refinements of the device resulted in a sensitivity to displacements of 0.00001 inch, with a contact circuit resistance of more than one megohm.

Using the grid glow micrometer it was possible to measure elastic deformation and elastic hysteresis of spring ribbon under stresses of the same magnitude as those used in spiral springs, and through load and temperature cycles very similar to the operating conditions of the spring. The test method provided a means for determining the effect on elastic hysteresis of such variables as: composition, cold working, thermal treatment and residual stresses, and temperature, duration, and intensity of loading.

Representative results of some of these tests, shown in Fig. 4, indicate the sensitivity of this method to elastic hysteresis effects. A heat treated ribbon of spring material was loaded for periods of 1 hour, 5 hours, and 25 hours, and the elastic recovery measured. As shown in Fig. 4 the recovery varies with log of time until complete recovery took place, and the rate of creep decreased with increasing time under load. With this knowledge it was possible through proper choice of material, and a closely controlled manufacturing process to reduce elastic hysteresis effects under usual operating conditions to negligible values.

◆ ◆ ◆ ◆ ◆

READERS' COMMENTS

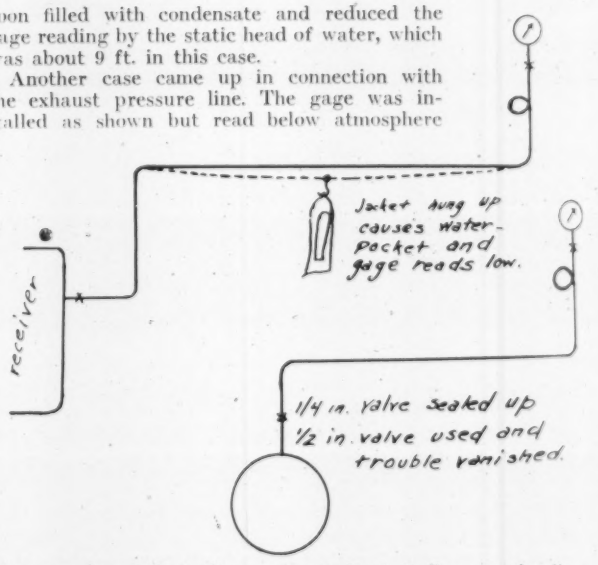
Editor, INSTRUMENTS:

THE importance of draining lines to low pressure gages is appreciated by most engineers and they are careful to avoid water pockets. Water will collect in either a steam or air line and cause errors in the reading if such pockets are left. If the gage is above the place where the line is tapped in, the head of water will cause the gage to read low. If the gage is below the level where it is tapped in, the head of water will cause the gage to read high. As this cannot be avoided the gage must be corrected to allow for the static head of water.

Occasionally even the most carefully installed line will not show up properly as shown by the two following examples which came up not long ago. The first was in connection with a gage on the receiver pressure of a cross compound engine. The line was about 40 ft. long in order to reach the instrument board without going through a concrete partition. I ran the line myself and know that it was installed so that there was no pocket and so that it would drain properly. Yet as summer came on the night engineer said he had difficulty maintaining the receiver pressure at the point where I told him it should be to divide the load evenly. Some nights he had to raise it considerably to get up to the pressure I set and that caused vibration.

It happened only occasionally but with increasing frequency so we began to get quite worried about it and I took the night shift a week to try and remedy the difficulty; but the engine would not perform for me so I gave it up, leaving word that the next time it happened I was to be called. Sure enough the pressure was down. I started to take the gage off to test it and a half gallon of water came out and I knew the trouble but was unable to account for it as I knew the line was up properly. Following it back, however, I discovered a jumper hanging from a wire hook attached to the ¼" pipe. The night engineer wore a jumper over from the change house as he found it got chilly during early mornings in the winter time. As it warmed up the jumper was too warm so he took it off and hung it on the pipe. The coat was heavy enough to bend the pipe and form a pocket and with the seal formed the pipe soon filled with condensate and reduced the gage reading by the static head of water, which was about 9 ft. in this case.

Another case came up in connection with the exhaust pressure line. The gage was installed as shown but read below atmosphere

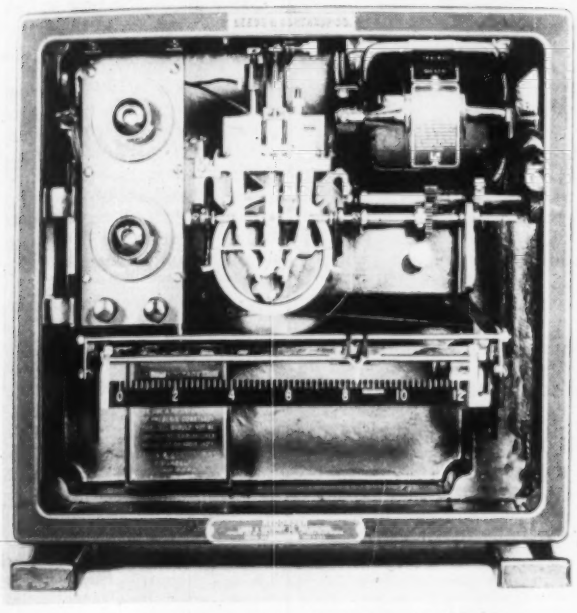

receiver
Jacket hung up causes water-pocket and gage reads low.
1/4 in. valve sealed up
1/2 in. valve used and trouble vanished.

when we knew that there was at least 3 lbs. on the line. We knew what the trouble was and figured that there was an obstruction in the pipe so took it to pieces and found nothing. When put back it acted the same way and as the only possible trouble could be the ¼" globe valve used we replaced it with reducers and a ½" valve and the trouble stopped. Apparently the circuitous path through the globe valve was so small that it sealed up and caused the line to fill with water. If I can't use a gate valve or cock I now make it a practice to come out of the main line with a ½" line and valve and then reduce it to a ¼" rather than run the risk of a similar difficulty.

Evanston, Ill. JOHN ALDEN
Feb. 26, 1932.

(Continued on page 92)

TELEMETERING — A Correction



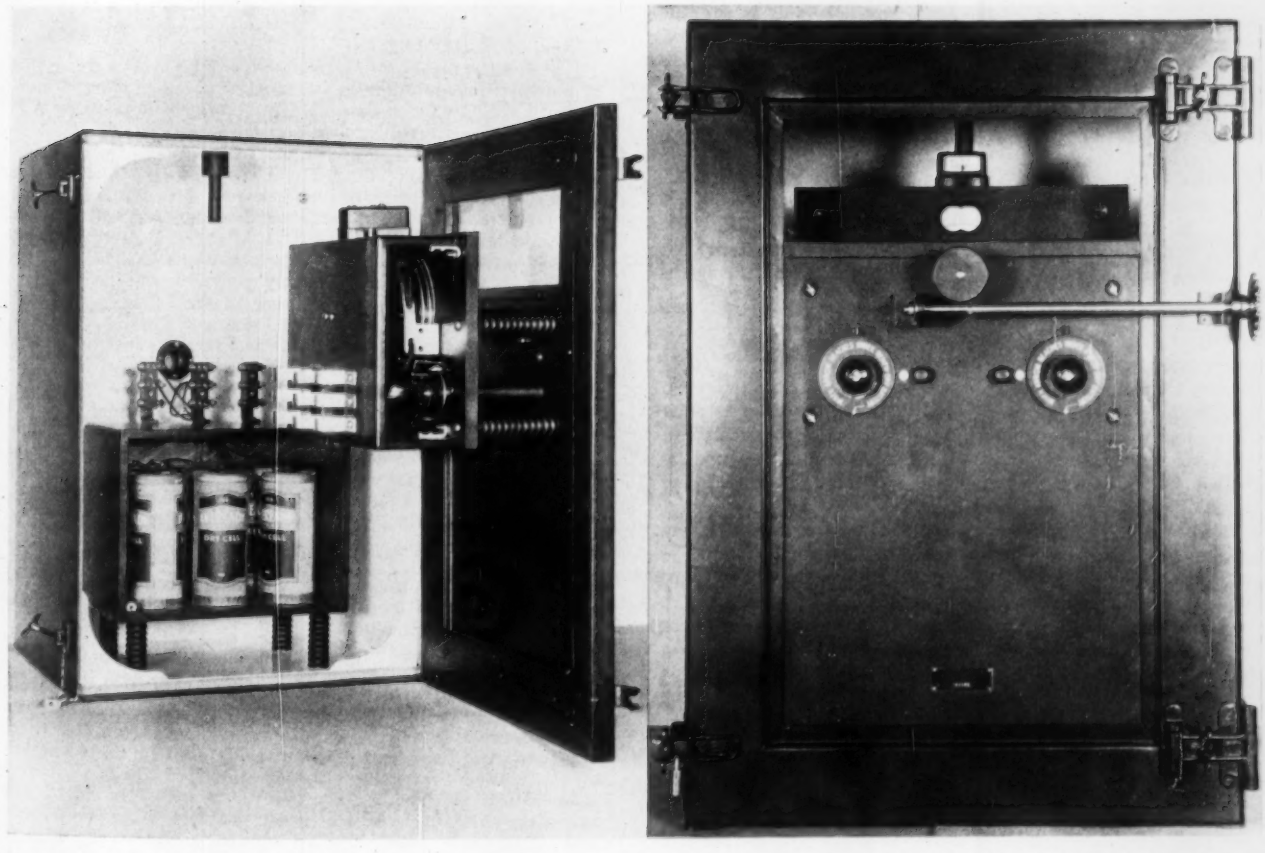
Telemetering Recorder for use with Lincoln Thermal Converter for Long Distance Transmission.

TO RECTIFY any erroneous impressions, which readers of INSTRUMENTS may have obtained, the editor below prints supplementary information on the Leeds & Northrup Telemetering System. For those who gained the impression from our article in the March issue that low cost and simplicity are the only features of the L. & N. system, the editor points out that the Leeds & Northrup Company requires more than this of their products. As is pointed out below this system is not limited to local transmission and one of the distinct advantages is that it does not use vacuum tube amplifiers. We therefore wish to call attention to the information below:

Electrical telemetering can be done with Leeds & Northrup equipment over distances ranging from approximately 100 miles down to a few tenths of a mile. Many kinds of readings may be telemetered—pressure, electrical load, flow, temperature, liquid level, etc. The principle is in all cases the same, and is illustrated by the following description of the L. & N. remote metering equipment, as installed by an electric company to record in the load dispatcher's office the output of a generating station nine miles away. This is one of over 40 installations.

Remote Metering by Thermal Converters

At the station there is installed a Lincoln thermal converter. This is an extremely simple device which, by means of thermocouples, generates a voltage that is accurately proportional to the load. It is connected to the station bus or transmission lines by the usual instrument transformers, and draws only 3 volt-amperes from each. It may be installed anywhere, in-



Open and Closed Views of Long Distance Transmitter for use with Westinghouse Motor Operated Graphic Wattmeter. Transmitter Circuits insulated for 20,000 volts above case.

doors, or out. It contains no moving parts, and requires no maintenance. It is termed the "transmitter" in the remote recording system.

In the dispatcher's office, miles away, is a standard Micromax recording potentiometer. It is connected to the transmitter by a pair of wires. For the sake of convenience, this is a telephone pair, leased from the telephone company, but it might be privately owned if desired. The pair is called the transmission line. The transmitter impresses its changing voltage (which is proportional to load) on one end of the line. The recorder, at the other end, impresses an opposite voltage from its slidewire. At intervals of a few seconds this voltage is automatically made to exactly equal, or balance, the transmitter's voltage, and between times of exact balance it does not differ materially from the transmitter voltage. This recorder voltage is simply recorded in terms of load, to match the voltage-load relation of the transmitter.

The engineering features of the equipment may be summed up in the statement that it makes true null measurements, inherently accurate and inherently permanent in accuracy. Only a small potential is used for transmitting readings, and yet the line resistance may be upward of a thousand ohms, because the voltage that reaches the potentiometer end of the line is only required to be great enough to swing the Micromax suspended-coil galvanometer away from center at times when the two voltages do not balance. Because the extent of galvanometer swing is of no interest, the amount of current that moves it is likewise unimportant. Hence any changes in line resistance due to temperature, contacts, etc., have no significant effect on the measurement.

If the load readings are to be transmitted over distances of the order of fifty or a hundred miles instead of five or ten miles, the transmitter may be modified in one of two ways. The result is either a potential balance or a current balance.

In the potential balance, a motor-driven retransmitting potentiometer is installed near the thermal converter on the transmission line. It measures the voltage output of the converter, and by means of its motor-driven slidewire impresses on the line a voltage that is exactly proportional to the converter voltage, but is much greater. The Micromax recorder at the other end of the line functions precisely as when the transmitter is only a thermal converter.

In the current balance an L & N Micromax controller and a rectifier unit are added to the thermal converter to form the transmitter. The controller opposes the converter potential by varying the current drawn from the rectifier. This is done in such a way that the potential drop across a coil in the transmitter is made to equal the potential produced by the converter. The current in the line is thus proportional to load, and the Micromax recorder simply measures it, being of course calibrated in terms of load.

Remote Metering with Westinghouse Graphic Wattmeters

In cases where a Westinghouse motor-operated graphic wattmeter is already installed, the L & N transmitter is a wall-type potentiometer, having its slidewire mechanically rotatable by means of a light chain drive from the shaft of the wattmeter.

Remote Recording of Pressure, Etc.

Obviously, the only change necessary in applying the L & N method to remote recording of other quantities than electric load, is to substitute transmitters that are sensitive to such other quantities. This is quite simple, and is demonstrated in the L&N remote pressure recording equipment. It is used by gas companies to record in pumping stations, the pressure in mains at points that may be 50 miles or more away.

The pressure transmitter is a compact device, in a weatherproof metal case, mounted on a post in the ground above the gas main. The transmitter contains an ordinary mercury manometer, connected into the gas line in the usual way. A steel float is carried on top of the mercury, and moves up or down with the mercury whenever the pressure changes. When the float moves, it slides a contact along a slidewire. This slidewire is part of a potentiometer circuit, and carries current from a pair of dry cells. Therefore, when the contact moves, the voltage drop between the point of contact and the end of the slidewire is changed. This changing voltage thus represents the changing pressure detected by the manometer. The Micromax recorder in the pumping station measures the voltage and records it as pressure in the way described above for electric load.

(Continued from page 90)

To the Editor of INSTRUMENTS.

We have subscribed to your excellent magazine for several years and looked forward to the receipt of each issue because of the valuable detailed information, as well as the arrangement of it. We have for convenience separated pages pertaining to Industrial Instruments (by Dr. M. F. Behar) as well as the advertisements, etc., and bound them together in different groups in our own manner. We wonder what advantages your magazine presents in its new form, except that it permits larger prints and advertisements. It certainly is not as convenient to handle and will not stand as much handling as your smaller size, which you will notice if you examine those sent through the mail. We have heard comment which corresponds to our ideas that the advertisements which you place on the margin of the same page as your technical discussion presents several disadvantages, as: the detraction of the mind when reading the article; the impossibility of filing this data without a lot of unassociated advertisements which, if filed, should be done so separately (our viewpoint); and the general appearance which it presents, giving the impression of a journal devoted more to advertising than to technical discussion which ourselves and associates value most highly.

We note the addition of your electronic department and are looking forward with interest to data on this subject, which in the past (particularly the Handbook of Industrial Instruments by Dr. M. F. Behar) you seem to have exercised exceptional talent in the concise, yet desired detail article, as well as the excellent arrangement and sub-classification, etc.

We are interested in your Current Literature Review, Catalog Library, Book Shelf, and New Instruments, as well as your Advertisement Index, and am glad that you are continuing them. No doubt you will include the Index to Volume 4 (1931) in one of your coming issues.

We do not as a rule enter into a discussion of this kind nor care to criticize, but probably because your articles have time and again answered our questions to the equivalent of almost a personal interview, we, in turn, have tried to picture your periodical as seen through the eyes of a reader.

Wishing you a most successful future and unhesitatingly recommending your magazine to our associates and friends, we are

Very truly yours,
ENGINEERING SERVICE CO.,
J. Victor Bertrand, Jr.
Chief Engineer.

Feb. 23, 1932
Riverside, N. J.

◈ ◈ ◈

Editor, INSTRUMENTS:

I wish to express my appreciation of the Abstracts section of the Instruments Magazine. I know of no other source wherein I can obtain as complete a cross section of developments in the fields of measurements and controls.

It is a tremendous help to me to know that with a few minutes of pleasant reading, I can keep myself abreast of the times and that there is available a reference file from which it is possible to obtain originals of those abstracts which seem of particular interest.

Please accept my heartiest congratulations.

Very sincerely yours,
Albert Allen
Vice-President
Atlantic Precision Instrument Co.

Malden, Mass.
March 26, 1932

◈ ◈ ◈

Atlas Electric Devices Co., Chicago, manufacturers of apparatus for predetermining the resistance of materials to sunfading, weather and washing, announces the appointment as its Pacific Coast Representatives of L. H. Butcher & Co., 271 Brannan St., San Francisco, with branches in Los Angeles, Portland and Seattle.

◈ ◈ ◈

The Kron Co., formerly the American Kron Scale Co., announces the removal of its plant and executive offices from New York City to Bridgeport, Conn.

◈ ◈ ◈

The Harry W. Dietert Company, Detroit, Mich., has secured sole rights from the United States Radiator Corporation to manufacture and sell the Cupola Iron Temperature Recorder. This patented temperature recorder is used in the foundries of the United States Radiator Corporation. The molten iron temperature may be readily controlled with the aid of the recorder, since each of the many possible improper cupola operations is recorded by a charontentic rise or dip of the temperature curve.

Flow Measurement and Control*

By M. F. BEHAR**

CHAPTER XXV

HEAD METERS

(Continued)

7. Commercially Available Primary Devices—General Considerations.

One of the most irritating experiences in any plant is that which follows the purchase of a differential manometer that has been advertised as a flow meter, when such an instrument is purchased by itself—without a properly selected primary element. In most cases, some engineer will have to devote much of his precious time to investigating the conditions of flow, to selecting a suitable means of producing a differential head measurable by the manometer, to installing the elements and connections (and reservoirs and air chambers, etc., if required) and finally to determining the multipliers and checking the installation.

The logical procedure would seem to be to decide first, from the conditions of the flow to be measured, what "class" of meter is called for and whether a meter of the kinetic head class *can* give satisfactory results. (Use Table VI-2, Chapter XXII.) Then refer to Sec. 1 of this chapter, to the sections below and to the more detailed specifications and characteristics of commercial primary elements which have been proposed by various manufacturers. Some types and models will be eliminated. For example if the fluid is a gas carrying particles

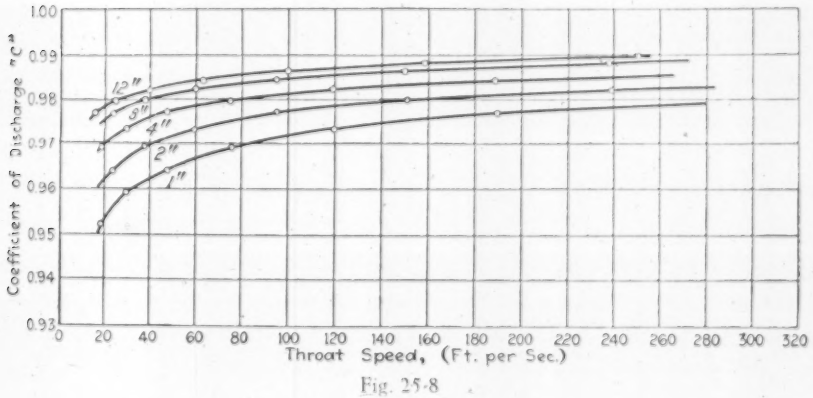


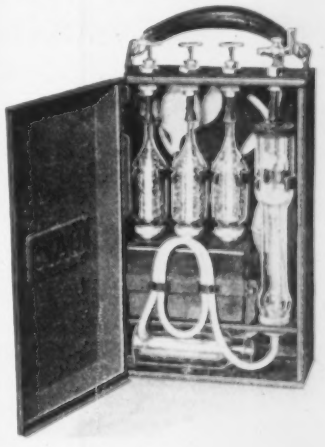
Fig. 25-8

of dust, most Pitot tubes will not do; if the pressure loss must be kept down, neither an orifice plate nor a flow nozzle will do; if space does not allow a Venturi, that type is eliminated; etc. As a rule there will be, after this elimination, a fairly wide choice not so much of types but of models. Some of these models will be unlike the "ideal" illustrations of text books; some will be altogether unlike the tentative "standards" laid down by various authorities.

A differential usable for metering may be obtained without purchasing a commercial primary element. Example, for water, a pipe bend or elbow smoothly finished inside. Note however that such cases are rare. Even in this case of using the centrifugal head, it would be well to obtain the proper fittings from a meter manufacturer specializing in such applications. Note also that the makers of indicating, recording and controlling elements and systems will not as a rule give any accuracy guarantees unless their instruments are used in connection with their own differential producers.

*Part VI of *The Manual of Instrumentation.*
**Engineering Editor.

Hays Apparatus
The Combustion Compass



HAYS GAS ANALYZER
For CO_2 only or for CO_2, O_2 and CO

1—Light weight! Compact!

2—Fast! CO_2 reading in 30 seconds by steel wool surface method of gas absorption. Complete analysis for CO_2, O_2 and CO in four minutes!

3—Toncan iron spot welded case, highly corrosion-resistant.

4—Monel Metal needle valves! Renewable nickel needle valve seats!

5—Cleaned in two minutes. All parts readily accessible.

6—Glass parts arranged to prevent breakage. Heavy one-piece moulded glass absorption pipettes attached to moulded hard rubber chemical bottles with soft rubber gaskets and finger compression nuts. All parts easily renewed in the field.

7—Can be carried in any position without spilling or mixing the solution.

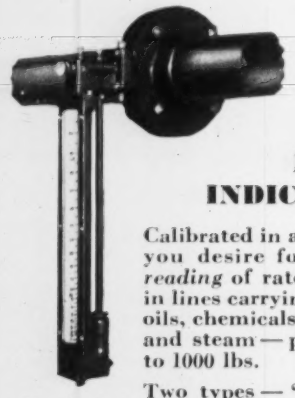
8—Convenient reels for rubber hose prevent kinking. More than 30,000 HAYS FLUE GAS ANALYZERS now in use all over the world.

Check the coupon for literature desired.

☐ Combustion Recorders.
☐ Flue Gas Analyzers and Portable Combustion Test Sets.
☐ Draft Gages.
☐ Treatise on "Handling the Orsat."
☐ Treatise on "Controlling Boiler Operation from CO_2 and Uptake Temperature."
☐ Treatise on "What Flue Gas Analysis Tells Us."

The Hays Corporation
MICHIGAN CITY, IND.

INSTANT KNOWLEDGE
of your flow conditions
with the



M J L
FLOW INDICATOR

Calibrated in any units you desire for *direct reading* of rate of flow in lines carrying water, oils, chemicals, air, gas and steam — pressures to 1000 lbs.

Close Hook-up Type

Two types — "Close" and "Remote" Hook-up.

Write for Bulletin 208, with interesting technical details . . . . *No obligation.*

▼

MOREY & JONES, Ltd.
Manufacturing Engineers
923 So. Hemlock St., Los Angeles, Cal.

P·Y·R·O RADIATION

PYROMETER

For temperatures exceeding 1000° F.

Requires no connection with furnace; no accessories; no installation.

Determines furnace temperature by sighting at object to be measured.

Always ready to tell within 3 seconds any shortcomings in your equipment.

It is serving many industries where heats must be measured accurately. It has no equal.

Does not require a skilled operator. Strictly automatic.

WRITE ALSO FOR OPTICAL—IMMERSION SURFACE BULLETINS

THE PYROMETER INSTRUMENT CO.
103 LAFAYETTE ST. NEW YORK, N. Y.

When a recorder is required, the choice of primary elements is limited to those for which commercial recorders and their charts are adapted. Even if the user is willing to order specially-printed charts—which should rarely be necessary—the range of the chart (the travel of the pen across it) depends on the range of the manometer which moves this pen. Therefore in specifying the primary device it is well, if possible, to arrange for a differential by which in *terms of flow* the pen travel will represent an even-number range, such as 0 to 10, 0 to 20, etc. For any available manometer range each recorder manufacturer has a number of charts so graduated that any one of them can be used with a multiplying chart factor equal to 10, 100, 1000, 10,000, etc. In other words, if the maximum flow to be measured is estimated at, say, 55,000 lb. per hour, a chart graduated "0" to "60" will no doubt be found to be carried in stock by the meter manufacturer and the multiplier will be exactly 1000.

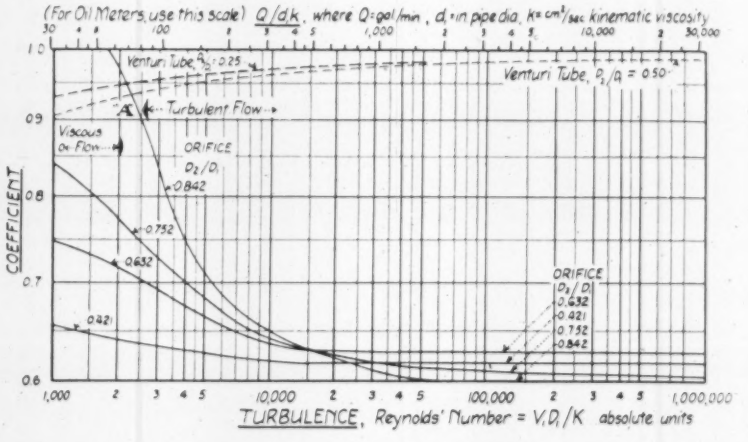


Fig. 25-10

A comparison of the characteristics of various primary devices in the region where the viscosity factor is important is shown in Fig. 25-10 prepared by Builders Iron Foundry (specialists in Venturi meters) from "published and other data available." They go on to say:

It covers a wide range of viscous oils and expansible fluids, as well as the usual coefficients for water, steam, air and gas. It is evident that the usual metering coefficient for most meters, even with moderately viscous oils, does not change greatly and that consequently a "flat" average coefficient is generally most satisfactory since corrections can then be applied easily for any fluid condition. The critical value where turbulent flow ceases is shown at A. Experience has shown that for general metering it is desirable to use meters of the rate type only in the turbulent region, i.e., for values higher than A. Below A the effect of upstream fittings and headers may be excessive. For such situations a reliable but variable coefficient may be obtained by using straightening vanes a short distance upstream from the meter.

For a similar comparison graph starting at a very low Reynolds value (0.1) see "Quantity-Rate Fluid Meters" by Ed S. Smith (of Builders Iron Foundry), A.S.M.E. Transactions, Fuels & Steam Power, 1929.

In selecting a primary element, the first endeavor should be to attain the desired *or required* accuracy at minimum costs (initial, running and maintenance). The distinction between desired and required accuracy is exemplified by the difference between two installations of steam meters where the physical conditions are alike but one is for metering steam to ten departments of a plant while the other is for metering steam to ten outside consumers who purchase it. Obviously, where close accuracy is not only required but demanded by economic considerations, the initial cost matters little because a slow meter might wipe out the profit; a fast meter might bring a costly lawsuit and any unreliable meter would have to be replaced; but the running and maintenance costs must be considered in advance as they may cut down the profits. One model of primary element may give a most dependable differential but if, on account of the nature of the measured fluid, it has to be inspected and cleaned frequently, such work should be carefully estimated before this particular model is finally adopted.

According to some authorities the Pitot type belongs with current meters, and if we leave it out there remain the quantity-rate meters for fluids in closed conduits. Ed S. Smith proposes recognizing only seven types of these: (1-3) three forms of Venturis; (4) the flow nozzle; and the square-edged orifice with (5) flange, (6) throat and (7) pipe connections. The author sticks to the A.S.M.E.'s view (which, as mentioned in Chap. XXII, is strictly followed in

this Handbook) but his own outline of the *forms* of primary devices of quantity-rate meters having proved useful for instruction purposes, it is given as follows in abreviated form:

1. *Friction.* Merely a pipe section calibrated for a certain fluid at a certain temperature, etc. Pressure taps are at the ends. This is the simplest primary device and in spite of its limited practical applicability must head the "series" (or, as will appear, the "cycle") of which it is the logical *start and end.*

2. *Centrifugal.* Again no flow-obstructing device in the conduit. Pressure taps at opposite sides or at 90 deg. Again simplicity and again limited applicability and necessity for calibrating.

3. *Segment.* The simplest differential-producing restriction. Ideally an infinitely thin diaphragm. Tap locations may be brought close.

4. *Concentric Orifice.* Ideally an infinitely thin plate. We now have a choice of manometer connections: "pipe," "throat," or "flange." Practically it has thickness. A slight increase in the thickness permits "integral" location of pressure taps. If we begin to round the edge and further increase the thickness we ultimately obtain the—

5. *Flow Nozzle.* On the downstream side, the diameter suddenly returns to that upstream. Manometer connections "pipe," "throat," "flange" or "integral." If we make this transition more and more gentle we ultimately obtain the—

6. *Nozzle with Recovery Tube.* If now we lengthen the nozzle until it becomes a conoidal section we reach the—

7. *Venturi,* in which there remains the "thickness" of the concentric orifice in the form of the throat section. Pressures are taken off at inlet and throat sections. If we lengthen the throat section we find it necessary to locate the throat piezometer at the entrance of this section by reason of friction loss. If we further lengthen and narrow the throat section and take off pressures at the Venturi inlet and at the *end* of the recovery cone we now have the transition between the Venturi and the—

8. *Capillary.* But since we are measuring the friction head, we can disregard the two conoidal sections and take off pressures at the ends of the narrow tube, which brings us right back to No. 1.

Theoretically, there is only One Best type, design and construction of differential producer for each particular application, depending on the normal rate of flow and the variability of this rate, the normal condition of the fluid and the variability of this condition, the size, location and position of the conduit, etc. Theoretically, therefore, there should be many different types, models and designs of primary elements in one average industrial establishment. And since theoretically there is only One Best instrument for each of these varied differential producers, there should be many different metering instruments in that same plant. Engineering theory, however, must often defer to practical industrial conditions, and in this branch of Instrumentation probably more than in any other, the "One Best Way" of scientific management can seldom coincide with the "optimum" of physics. In fine, one must recognize the practical advantages of standardization. The point we wish to make is that standardizing on one make and model of instruments, merely in order to have neat-looking meter houses or handsome panel boards, and in order that all charts in the plant should be of one style, may result in some instruments being more ornamental than useful. One of the best run plants that the author has visited is a large chemical works where of course accuracy of fluid metering and control is extremely important. It uses more different makes of flow instruments than we can remember.

It may be well to bear in mind that head meters are still in their infancy—if we consider the class as a whole. One type, the Venturi, is well established in that the factors affecting its accuracy are known and correctly evaluated. The other types are not: Moss, Oliphant, Bacharach, Weymouth, Spitzglass, Bailey, Diehl, Hickstein, Cooper, Westcott, Hodgson, Levin, Buckingham, Litinsky, Bean, Smith, Loeb, Pigott, Fechheimer and other pioneers in metering with orifices, Pitot tubes, etc., are not 19th century names but our contemporaries—and most of them are still accumulating the necessary data to make a science out of an art. At the conclusion of his 1929 Oklahoma address Weymouth declared that "the orifice meter is an instrument of laboratory precision worthy of the highest confidence *if properly used.*" To which one might add "*if the installation,* including parts outside the elements of the meter and sometimes remote from it, *is correct.*"

In the five sections which follow (§8 to §12) there are illustrated and described a number of primary devices including some the construction of which differs from the descriptions of the "types" in Section 1. These sections are not a comprehensive directory. Some excellent devices on the market are

MANUFACTURERS' LITERATURE

In this department we each month list the printed matter issued by manufacturers. Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter are invited to do so.

34 Fuses. Catalogue No. 4 describes low range fuses for instruments, radio receivers, radio amplifiers, and radio transmitters. Littelfuse Labs., 1772 Wilson Ave., Chicago, Ill.

35 Resistance Bridges. A circular showing several kinds of bridges that have been developed to cut manufacturing costs, or to simplify laboratory routine. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

36 Mounting Base. A circular, identified as Supplement No. 1 to Catalogue No. 48 describes a Type T Mounting Base arranged so that it is possible to mount on it any metal or bakelite case, flush mounted, instrument of Type T. Other circulars by this company are: Supplement No. 1 to Bulletin No. 240 on Surface Tension Balance, designed especially for measuring the surface tension of liquids; and Supplement No. 2 to Bulletin No. 300 on Circuit Testers. Roller-Smith Company, 233 Broadway, N. Y.

37 Magnetic Counter. A looseleaf circular describing a Dunco Electric Magnetic Counter—non-resetting and resetting types. Struthers Dunn, Inc., 139 N. Juniper St., Philadelphia, Pa.

38 Time Switches. Publication No. 10 illustrates and describes triplex time switches to control illuminating circuits for stores, show windows, poster boards, signs, etc. Triplex Products Corp., Clifton, N. J.

39 Leakage Recorder. Circular 23151-G announces a "Micromax" Recorder which shows directly the percentage of cooling water that has leaked into the condenser. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

40. Scales. Circular 2420-G shows the index of the box-type galvanometer which is now a sharply-focused bar of shadow, bisecting a circle of brilliant white light. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

41 The Modern Lamp of Aladdin is the title of a folder describing the light sensitive cell unit. It is composed of a midget relay; special transformer; tube socket to accommodate a standard 112-A tube; condenser, together with a self-contained light sensitive cell unit, not of the vacuum tube design. Struthers Dunn, Inc., 139 N. Juniper St., Philadelphia, Pa.

42 The Graphic. No. 1031 of this publication contains an article entitled "The Use of Contact Making Instruments." The Esterline-Angus Co., Indianapolis, Ind.

43 Colorimeter. A 12 page booklet identified as List No. 200 describes a direct reading Duboscq Colorimeter. Hellige, Inc., 179 East 87th St., New York.

44 The Fog Horn. The December, 1931, issue of this publication features an article by Prof. E. R. Schwarz entitled "Mill Control Laboratories." Parks-Cramer Co., Fitchburg, Mass.

45 Instruments. General Pamphlet No. 297-C features measuring tools and special machines for production on a high precision basis; General Pamphlet No. 365-B features instruments for scientific institutes; Leaflet No. 465 describes a drum dividing machine; Leaflet No. 479 describes comparators for the measurement of photographic plates; and Leaflet No. 525 describes and illustrates six measuring microscopes. The R. Y. Ferner Co., Investment Building, Washington, D. C.

46 Speed Motors. Bulletin No. 1667-B describes and illustrates constant speed motors. These motors assure a high degree of reliability under severe operating conditions. Bodine Electric Company, Oakley Blvd. and Ohio St., Chicago, Ill.

47 Calendar. A 12 page art gravure calendar, 24 inches by 15 inches, each page illustrating material handling screening or positive power transmission equipment. Link-Belt Company, 910 S. Michigan Ave., Chicago, Ill.

48 Water Works Journal. December, 1931, issue of this publication features the following articles: "The Establishment of Water Rates. How to Go About It"; "The Telemco System." Pittsburgh Equitable Meter Co., 400 Lexington Ave., Pittsburgh, Pa.

49 Prismatic Derivator. Pamphlet Geo 106-E describes a prismatic derivator used for indicator diagrams for finding the horse-power of engines, time-speed curves for determining the acceleration of vehicles, camlift curves, calculations on heat transfer, etc. American Askania Corporation, 809 M. & M. Building, Houston, Texas.

50 Apparatus. Bulletin No. E-11 entitled "Melting Point Apparatus," which has been developed for the purpose of providing an easy, rapid, and accurate means for determining the melting points of various materials. The Burgess-Parr Company, 111 West Monroe St., Chicago, Ill.

51 Spectrophotometry. Publication No. 156/1 describes outfits for absorption spectrophotometry, a guide to the choice of suitable spectrophotometric apparatus for (a) the ultra-violet region and (b) the visible region. Adam Hilger, Ltd., 24 Rochester Pl., Camden Road, London, N. W. 1, England.

52 Oiliness Machine. Bulletin No. 112 illustrates and describes the Herschel Oiliness Machine for testing the friction reducing properties of lubricants and bearing metals. American Instrument Company, 774 Girard St., N. W., Washington, D. C.

53 Conductance of Electrolytes. "A Bridge for the Measurement of the Conductance of Electrolytes" is the title of a reprint from the July, 1931, issue of The Review of Scientific Instruments, Leeds & Northrup Co., 490 Stenton Ave., Philadelphia, Pa.

54 Gravity Recorders. Bulletin No. 192 describes gravity recorders for liquids. It illustrates how the gravity recorder continuously records the specific gravity of a liquid and automatically corrects its record for variations in the temperature of the liquid. Bailey Meter Co., 1050 Ivanhoe Road, Cleveland, Ohio.

55 Mercury Thermometers. A number of descriptive leaflets devoted to mercury temperature measurement and control devices. Another booklet issued by this company is entitled "Mercury in Steel Thermometers." Negretti & Zambra, 38 Holborn Viaduct, London, England.

56 Catalytic Hydrogenation. Bulletin No. E-13 describes apparatus for catalytic hydrogenation, which provides a means for studying the hydrogenation and condensation of organic compounds. Burgess-Parr Company, 111 West Monroe St., Chicago, Ill.

57 Chlorine Control. A small booklet published for the purpose of rendering service to everyone interested in pH and chlorine control. W. A. Taylor & Co., 872 Linden Ave., Baltimore, Md.

58 Polishing Machine. A circular describing an automatic metallographic polishing machine. A similar circular by this company describes the sayboltype constant temperature viscosimeter. American Instrument Co., Inc., 774 Girard St., N. W., Washington, D. C.

59 Comparators. Bulletin No. 126, entitled "Optical Instruments of Recent Design," describes the following: Comparators; Rapid Setting Wavelength Spectrometer; Ultra Violet Monochromator and Polarizing Spectrophotometer. The Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago, Ill.

60 Potentiometer Pyrometer. Circulars 239-P and 290-P describe the improved potentiometer which is fully automatic, needs no manual adjustments and requires no daily attention. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

61 Regulator. Bulletin No. 205 describes the Type D K regulator for combustion control. It is adaptable to practically any requirement where it is desired to vary control equipment in direct relation to pressure changes. Morey & Jones, Ltd., 922 So. Hemlock St., Los Angeles, Calif.

not described. The design is to suggest rather than to list. For example it will be noted that there is no sharp dividing line between the true Venturi type and the true flow-nozzle type, nor between the nozzle and the orifice.

Instead of starting, as in the foregoing sections on the theory and principles of measurement, with orifice plate elements (which are the most widespread) the following sections start with the long, slowly contracting Venturi without "corners," and lead on progressively to the orifice plate. The carefully selected illustrations have been so arranged in progressive order as to convey the most useful view of the variety of designs on the market, and the text—briefly descriptive—follows this scheme. In line with this purpose there are illustrated (or merely described in the text) devices neither illustrated nor described in the A.S.M.E. report just issued; and in order to make it easier for the reader, illustrations are not multiplied repetitiously as would have been the case if we merely wanted to be "fair" to many different makers of almost identical devices. After the orifice plate comes a break in the descriptions, Sec. 11 on installations being inserted as it applies especially to the differential producers that precede it and applies little to Sec. 12, where the descriptions are resumed with Pitot primary elements and concluded with miscellaneous devices.

8. Venturi Devices.

Rather than having been "standardized," the proportions of Venturi tubes have simply remained by universal consent those adopted in 1889 by Herschel who invented the Venturi meter. Fig. 25-2 (in Sec. 1) shows these proportions and the usual construction. Note that the throat section has a special liner. Some makers supply Venturi tubes with both inlet and throat section liners of special materials carefully machined and finished to dimensions. The shape of the throat is critical. Imperfect design or finish causes cavitation errors. Better use a good orifice than a questionable Venturi.

There is no limit to the size of a Venturi tube. For waterworks, etc., they are frequently made of concrete, with built-in cast iron inlet and throat rings. Below are extracts from one maker's tables of capacities of his standard tubes:

Inlet & Outlet Dia. In.	Throat Dia. In.	Length	Appr. Weight Lb.	WATER U.S. gal./min.		STEAM at 100 lb. lb./hr.	AIR at 100 lb Dry Rate Q Cu. ft./min
				Min.	Max.		
2	⅛	2 3/8″	60	3	35	1100	390
2	¾	2 1/4″		4	55	1600	550
2	1	19″		7	90	2900	1000
12	4	11′ 0″	1550	110	1440	45000	15500
12	5	9′ 11″		175	2260	71000	25000
12	6	8′ 10″		250	3250	105000	36000
60		51′ 8″	58300	2780	36100		
60		46′ 3″		4340	56400		
60		40′ 10″		6250	81300		

"Long" and "short" Venturi tubes are made by the International Filter Co. The proportions of the "long" Venturi, judging from the blueprints, should give practically the same coefficient and other characteristics as those of the Venturi illustrated in Fig. 25-2. Extracts from this maker's specifications:

" . . . Flanged, bell, or spigot end connections . . . The vents to the inlet pressure chamber will be bronze bushed, those to the throat pressure chamber being through the bronze liner at its minimum diameter. Tubes for clean fluids will be furnished with a series of tapped holes in the outside face of each pressure chamber, plugged, each hole directly in line with each vent, to permit a cleanout of vents if necessary at any time."

Venturi inlet cones or "measuring sections" including the usual design of piezometer chambers at inlet and throat are made by the Simplex Valve and Meter Co. with the small end so arranged that the Venturi recovery tube can be constructed of any desired materials. The Republic Flow Meters Co.'s Venturi

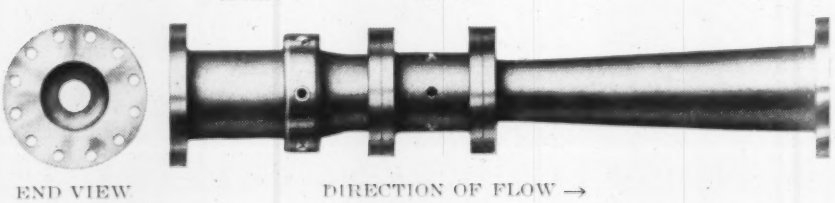


Fig. 25-11

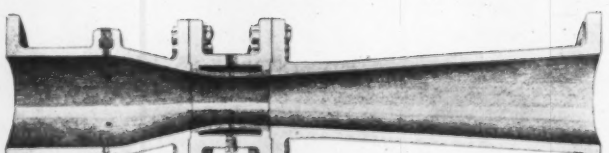


Fig. 25-12

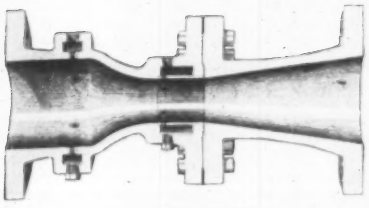


Fig. 25-13

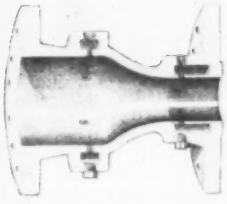


Fig. 25-14

tubes are of the accepted proportions, the standard Republic "long" design having liners at both inlet and throat; the "short" design at throat only. "All Republic Venturi tubes are made up special in accordance with the requirements of the installation." Builders Iron Foundry's "Herschel standard" form is shown in Figs. 25-11 and 25-12. It is made in standard sizes (inlet and outlet diameter) of 2 to 60 inches. Interchangeable throat sections make possible changes of capacities. (The instrument is then correspondingly altered by substituting new dials.) A special form of Venturi tube which can be inserted *wholly* within pipes and mains is the Simplex Valve & Meter Co.'s "Type TG." When the "measuring section" alone is inserted the low pressure connection is at the throat (as in all true Venturis) but the high pressure tap is a pipe connection upstream from the inlet of the cone. Now, if a downstream pipe connection were used for the low pressure, the coefficient would be in the family of nozzle coefficients and in fact the whole primary device, with no other alteration, would be virtually not a Venturi but a flow nozzle.

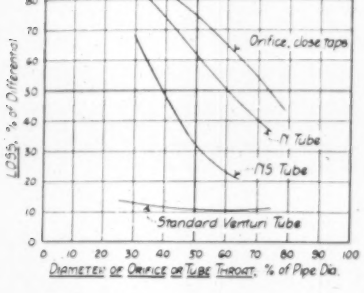

Loss, % of Differential
Orifice, close taps
N Tube
NS Tube
Standard Venturi Tube
Diameter of Orifice or Tube Throat, % of Pipe Dia.

Fig. 25-15

Fig. 25-15 supplements the pressure-loss curves given in Sec. 4. It is taken from a publication of Builders Iron Foundry for the oil industry and shows the pressure losses for various types of differential producers working under conditions where there is no appreciable correction for viscosity, i.e., for turbulent flow above *A* in Fig. 25-10. It will be observed that the Venturi tube has comparatively small losses; "Style NS" (which is the Venturi nozzle Fig. 25-13) slightly more loss; "Style N" (Fig. 25-14) practically the same loss as the thin plate orifice. "For heavy viscous oils the loss through the Venturi tube increases somewhat, but such loss is seldom important."

9. Flow Nozzle Devices.

The conventional design was shown in Fig. 25-3, with downstream tap in the plane of the end of the nozzle throat where the measured pressure is almost exactly the static pressure within the jet at its section of parallel flow and maximum speed. The practical designs of commercial devices include some with the downstream tap thus exactly located, and others with different arrangements. The calibration data shown in Fig. 25-9 apply not only to this downstream tap location but also to a "pipe connection" one pipe diameter ahead of the entrance, because a higher pressure is registered in the corner close to the entrance. Therefore, apart from the contour factor, there are various coefficients obtainable with the various devices on the market, the connections of which are differently located, as may be seen by glancing over the illustrations.

The V.D.I. (Society of German Engineers) has adopted detailed standard specifications for contour of flow nozzles, location of connections, etc. This standardization has made it possible to accumulate an enormous amount of related data and to interpret them, in which work Dr. Buckingham and other Americans have participated. Whether or not this foreshadows standardization of flow nozzles in this country, these German nozzle data covering studies with water, air, steam and gases are of the highest interest.* Several unexpected phenomena were found which "may serve as a warning against the use of insufficiently investigated metering arrangements."

For reliable metering and especially for use with recorders with standard charts, flow nozzles should be bought only from makers who take pains to make the flare properly shaped (to their own or any consistent specifications), per-

*L. M. Van der Pyl, Chief Chemist of the Pittsburgh Equitable Meter Co. has been translating recent important paper by Nusselt, Richter, Witte and others (not only on flow nozzles but on other fluid metering subjects) and is mailing copies to members of the A.G.A. and A.S.M.E. committees and other interested persons. The author hereby expresses his thanks to Mr. Van der Pyl.

62 Experimenter. The December, 1931, issue of this publication contains the article, "A Piezo-Electric Oscillator of Improved Stability.", General Radio Company, 30 State St., Cambridge A., Mass.

63 Gearmotors. A leaflet identified as L. 20536 describes gearmotors consisting of speed reducers combined with induction motors. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

64 Counter. Catalog, Section No. 15, entitled "The New Pre-Determined Counter," which will stop a machine, flash a light, ring a bell or actuate any other electric signal at any pre-determined figure, while also keeping a running total of production. Durant Mfg. Co., 1925 N. Buffum St., Milwaukee, Wis.

65 Testing Instruments. Circular H-1 describes two types of portable hardness testing instruments. One is a pendulum type of hardness tester, called the Duroskop, which is used to test metals, ceramics, rubber, plastic, vulcanized products, etc.; the second is a Dwarf Brinell Press which can be used in any part of the shop where a vise, arbor press, drilling machine or large C clamp is available for applying the pressure. The R. Y. Ferner Co., Investment Building, Washington, D. C.

66 Chemical Apparatus. Several Bulletins identified as follows: No. 472, "Eppenbach Colloid Mills," laboratory and industrial types; No. 478, "Seitz Germproofing Laboratory Filters"; No. 480, "E. & A. Model Twenty Flask Ross-Kershaw Shaker"; No. 482, "Yandell Henderson Syringe Gas Analyzer," for oxygen tent atmosphere tests and other rapid approximate gas analyses. Eimer & Amend, Third Ave., 18th to 19th St., New York, N. Y.

67 Ceramic Kilns. Bulletin No. 360-A, describing a high temperature test kiln, which has been developed to meet the need for a small muffle furnace or kiln capable of reaching a high heat quickly and safely. The Denver Fire Clay Company, Denver, Colo.

68 Gage Blocks and Accessories. A booklet describing gage blocks used to check the size and accuracy of inspection and production gages. This booklet is found to be a handy reference as a complete catalog for gages and accessories. C. E. Johansson, Inc., Division of Ford Motor Co., Detroit, Mich.

69 Indicator. Bulletin No. 89, entitled, "M-S-A Continuous Carbon Monoxide Indicator," which is a portable instrument designed to continuously indicate low concentrations of carbon monoxide in air. Mine Safety Appliances Co., Braddock, Thomas and Meade Sts., Pittsburgh, Pa.

70 Control Equipment. Bulletin No. 1212 and supplementary data sheets describe and illustrate motor operated controller; time cycle contactors; motor operated valves, and motor operating relays. Automatic Temperature Control Co., Inc., 34 East Logan St., Philadelphia, Pa.

71 Promar is the title of a five-page circular. This promar is a compact apparatus of superior construction and simple to operate. It is particularly adapted for projecting prepared slides, living organisms and insects on screen or table for demonstration or drawing. Clay Adams Co., 117 East 24th St., New York, N. Y.

72 Engineering Achievements of 1931 is the title of a Reprint identified as No. 471 and taken from the January, 1932, issue of the Electric Journal. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

73 Regulators. Bulletin No. 5501 describes constant wattage voltage regulators, and economical solution of alternating current voltage variations in photo-cell applications. Ward Leonard Electric Co., Mount Vernon, N. Y.

74 Oscillator. A circular describing Model "E-2" short wave oscillator. Lepel High Frequency Laboratories, Inc., 39 West 60th Street, New York.

75 Air Filters. Bulletin No. 500-1, November, 1931, entitled Norblo Continuous Operating Air Filters. These filters are automatic in action, self-cleaning and are furnished in various sizes. The Northern Blower Company, West 65th St. and Barberton Ave., Cleveland, Ohio.

76 Level-Tension Handle. A circular illustrating and describing the level-tension handle developed in response to the demand for better taping without extra work or loss of time. Brandis & Sons, Inc. 754 Lexington Avenue, Brooklyn, N. Y.

77 X-Ray. A two page folder entitled "Secrets of Metal as Revealed in Welds by Means of the X-Ray." Claud S. Gordon Company, 708 West Madison Street, Chicago, Ill.

78 Parks' Parables. The March, 1932 issue of this publication features the article, "Amateur Economics." Parks-Cramer Company, Fitchburg, Mass.

79 Clock-Mirror. A circular describing an 8-day jump-hour timepiece combined with a non-glare mirror. Jaeger Watch Company, Inc. 304 East 45th Street, New York, N. Y.

80 Balances. A 23 page booklet describing and illustrating laboratory precision balances. The Heusser Instrument Mfg. Co., 165 Pierpont Avenue, Salt Lake City, Utah.

81 Curd-O-Meter. Bulletin 45 describes a curd-o-meter used for testing the curd hardness of milk. Another piece of literature by this company is bulletin 27 describing the chain-poise variable weight analytical balance used for quick and accurate weight determinations. The Heusser Instrument Mfg. Co., Salt Lake City, Utah.

82 Salt-Spray Equipment. Bulletin 1506 discusses the latest U. S. Navy method salt-spray equipment for determination of corrosion resistance, and its value to both producers and consumers of ferrous alloys. The American Instrument Company, 774 Girard St., N.W., Washington, D. C.

83 Refractometers. A 19 page booklet entitled "Abbe and Dipping Refractometers." Bausch & Lomb Optical Company, Rochester, N. Y.

84 Engines. Bulletin 3266 relates the correct compression essential for the safety and efficiency of Diesel Engines. Bacharach Industrial Instrument Co., 7000 Bennett St., Pittsburgh, Pa.

85 Transits and Levels. A circular describing and illustrating five models of engineers' transits and levels. The L. Beckman Co., Toledo, Ohio.

86 Pyrometer. A letterhead circular describing a Pyro optical pyrometer. The Pyrometer Instrument Co., 103 Lafayette Street, New York, N. Y.

87 Precision Tools. A handbook instructive and helpful to anyone who has contact with precision work. The Taft-Peirce Manufacturing Co. 32 Mechanic Avenue, Woonsocket, R. I.

88 Motor Starters and Push Buttons. A circular describing explosion-proof motor starters and push buttons for providing safe operation in oil refineries, gasoline plants, lacquer plants, etc. Bulletin 1048 by this same company describes EC & M Type ZO Starting Switches for small A. C. Motors. The Electric Controller & Mfg. Co., Cleveland, Ohio.

89 Draft Gage. Catalogue PGA-32 describes indicating and recording gages. The Hays Corp. Michigan City, Ind.

90 Regulator. Catalogue No. 5 entitled "The Mercon Regulator," is an attractive 28 page book describing feed water excess pressure regulators, constant reduced pressure regulators, constant flow regulators, liquid level controllers, etc. The Mercon Regulator Company, 1 LaSalle St., Chicago, Ill.

91 Electric Instruments, is the title of Catalogue No. GEA-602B and this publication furnishes information on standard lines of switchboard, portable and laboratory instruments, also dimensions, typical scales and wiring diagrams of certain lines are included. General Electric Company, Schenectady, N. Y.

92 Parks' Parables. The January 1932 issue of Parks' Parables features the article, "Health in the Air We Breathe." Parks-Cramer Company, Fitchburg, Mass.

93 Power Demand. A circular describing how to reduce operating costs by controlling electric power demand. Power Control Corporation, 410 North State Street, Syracuse, N. Y.

94 Timers. A circular describing Gallet Timers. These timers feature non-magnetic movements, lever escapements, shock proof construction and cases which are chrome-finished. Jules Racine & Company, 20 West 47th Street, New York, N. Y.

fectly smooth and free from all irregularities, and to make the end of the throat concentric and free from taper. Errors as large as several percent, declares the A.S.M.E. report, have been found in calibrating nozzles which were produced without paying strict attention to these details in machining. Additional tests have been obtained for nozzles having diameter ratios somewhat larger than 0.85, but the curve becomes so steep beyond this point as to be almost prohibitive in use. In addition, it is impossible to go very far beyond this limit, due to the physical limits of lack of clearance between the throat and the pipe at the higher diameter ratios.

Fig. 25-16 shows the appearance of a representative flow nozzle of the spun type (Bailey Meter Co.) for ordinary pressures. This form of nozzle is clamped between any existing flanges. Flow nozzles used in the measurement of water, air, and oil are made of bronze, while those for steam are usually made of steel. On installations where an exceptionally high degree of accuracy is desired, several firms are prepared to supply fabricated pipe sections with the nozzle or orifice already installed. This type of construction insures the accurate installation of the nozzle and nipples in a section of pipe which is absolutely smooth and of uniform, circular cross-section. There are on the market a number of styles of such flow nozzle units. Fig. 25-17 is a section of the Bailey Meter Co.'s assembly for pipes larger than 3 in. The tube is bored to a diameter conforming to that of the pipe immediately preceding it, and the nozzle throat is bored in place to assure exact alignment with the tube. Doweled flanges hold the nozzle and can be separated to change nozzles when capacity is desired to be changed. Other features are lettered on the drawing. Fig. 25-18 is another Bailey flow nozzle assembly, for pipe sizes under 4 in. Fig. 25-19 is a section of the Foxboro Co.'s flow nozzle for high velocities, the shape of which is laid down in uniform specifications. Note that the downstream tap is located exactly in the plane of the end of the nozzle. Each nozzle is machined "with great precision to the exact dimensions necessary for the particular requirements." Bronze is regular, steel, Allegheny metal or chromium steel optional. The Bacharach Industrial Instrument Co.'s flow nozzle assembly, Fig. 25-21, has a nozzle of thin aluminum and special fittings as shown, including a piezometer ring. It is designed especially for air and gases and an interesting application, Fig. 25-20, is metering air supply to blast furnaces, etc., for which the instrument is really a "vacuum gage" since the differential head translated in terms of flow is the

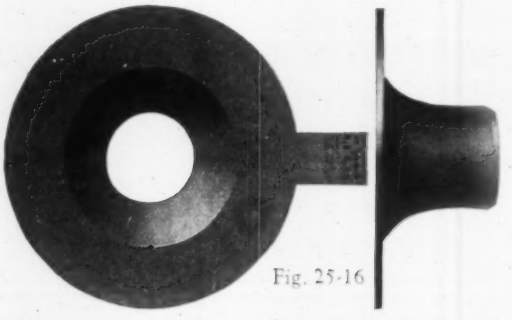


Fig. 25-16

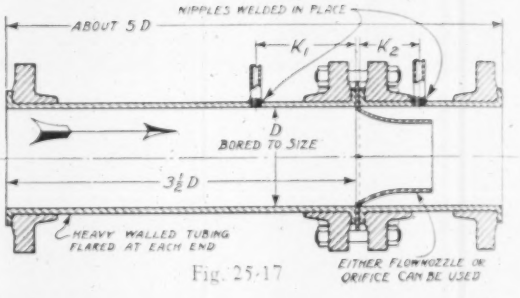


Fig. 25-17

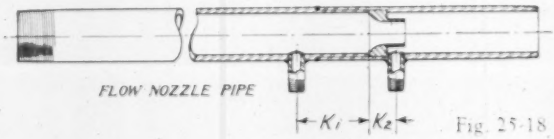


Fig. 25-18

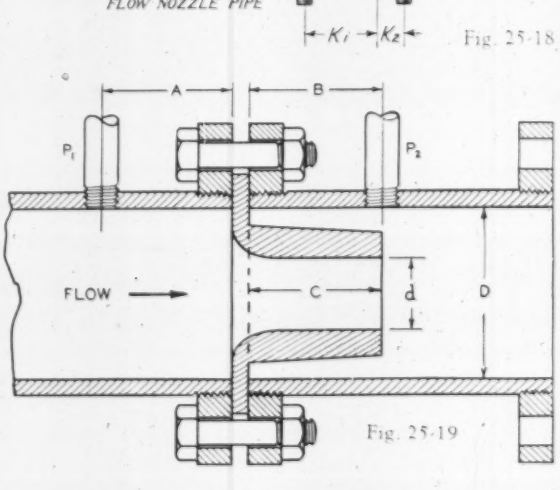


Fig. 25-19

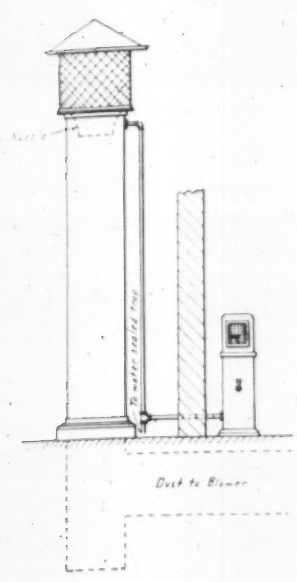


Fig. 25-20

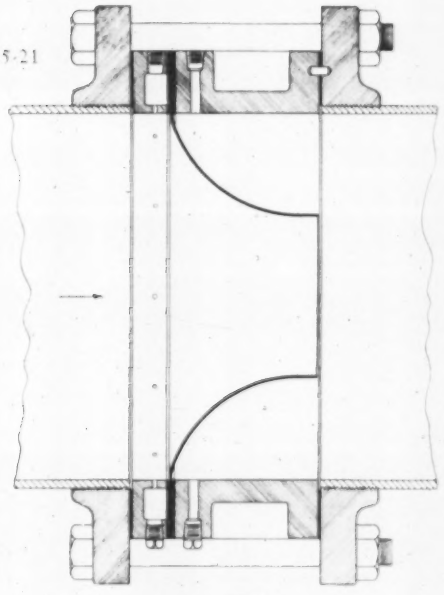
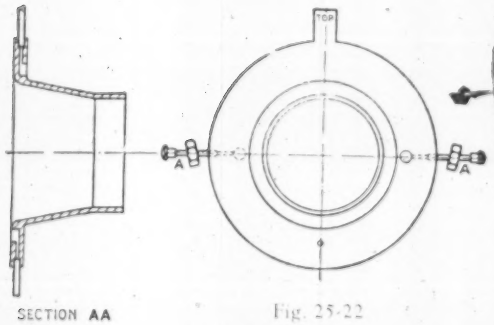


Fig. 25-21



SECTION AA

Fig. 25-22

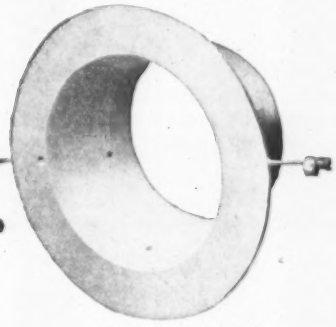


Fig. 25-23

difference between barometric pressure and absolute pressure on the downstream side of the nozzle.

The closest possible location for up- and downstream taps is achieved in the Cochrane Corp.'s flow nozzles with integral pressure connections, Figs. 25-22, 23, which not only dispense with the need of drilling and tapping the pipe (and thus eliminate, as do all ready connections, possible errors due to improper pipe taps) but may be located closer to fittings and valves than other forms of primary elements. (See Sec. 11.)

10. Orifice Devices.

This is the most widespread and best known type of primary element, also the most diversified in its commercial forms. The ideal arrangement, illustrated in Sec. 1, would be impractical, hence numerous solutions. The many styles available may be classified in several ways. First, according to the shape and position of the orifice with respect to the cross-sectional area of the pipe. This gives three distinct sub-types shown in Figs. 25-25 to 25-27 the captions of which discuss the respective characteristics. Second, by the location of the pressure taps, beginning with locations more than one pipe diameter on both sides, and ending with integral connections. The illustrations are arranged somewhat along this classification. A third classification of the devices on the market is simply into those that come with pressure connections and those that require that the pipe be drilled.

Orifice plates should be handled with great care. Fig. 25-24, from the Foxboro Co., deserves study. All reputable makers take infinite pains to machine the orifices to exact dimensions, with tolerances seldom exceeding 0.1 percent of the orifice diameter. Good plates have the orifice diameters correct to 0.001 in. The importance of this may be shown by an example: Pipe size, 4 in., specified orifice diam., 1.000 in., actual diam. 1.005 in., error + 1.036 percent. Careless use of abrasives in cleaning a plate, resulting in an almost imperceptible rounding of the edge, may throw the measurement 4 or 5 percent off.*

*The most instructive set of graphs showing variations of orifice coefficients caused by irregularities, etc., appears in "A Study of Primary Metering Elements in 3-in. Pipe" by Beither, Bucher and Barnes, *Trans. A.S.M.E.* 1931.

95 Lenses. A booklet dated May, 1931, entitled, "New Standards of Perfection in Lenses." Adam Hilger, Ltd. 24 Rochester Pl., Camden Rd., London, N.W.1, England.

96 Micro-Galvanometer. A 12 page pamphlet featuring the moll micro-galvanometer. This moving coil galvanometer is characterised by its very short period which renders it useful for rapid observations, for measuring frequent fluctuations in electromotive forces, etc. P. J. Kipp & Zonen, Delft, Holland.

97 Valves. Bulletin 127 describes and illustrates solenoid operated valves, of packless construction for air, gas, brine, water, oil, etc. Electric Valve Manufacturing Co. 68 Murray Street, New York, N. Y.

98 Weigher. A circular showing the Hamblin Accurate Weigher with the Commercial Standard Weigher, a comparison of both these weighers is given. They are both manufactured by The Hamblin Accurate Weigher Company, North Olmsted, Ohio.

99 Ground Tester. Bulletin 1300 describes the "Meg" ground tester, an instrument for testing the resistance to earth of ground connections, such as transmission towers, buried plates, driven rods, and pipes. James G. Biddle Co., 1211 Arch Street, Philadelphia, Pa.

100 Gages. Technical Publication No. 150 describes remote recording meters and gages. Another piece of literature published by the same company is one on specializing in chlorine control apparatus, for all phases of chlorination in sanitary and industrial fields. Wallace & Tiernan Products, Inc. Belleville, N. J.

101 Temperature. Catalogue No. 4001 entitled, "Free Vane Air Operated Recorder Controller Equipment." The Bristol Company, Waterbury, Conn.

102 Bearings. A letterhead folder describing sapphire settings of sapphire bearings. A few of the many methods of mounting fine precision bearings. The Industrial Jewel Co., Inc., 26 Bedford Street, Waltham, Mass.

103 Pressure Gage. Catalogue No. 1011 supplementary to No. 1010 describes and illustrates recording absolute pressure gage. The Bristol Company, Waterbury, Conn.

104 Meters. A booklet identified as O. C. Watthour Meter, which was developed to contribute to the improvement and simplification of metering. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

105 Electrocardiograph. Bulletin No. 275 describes the Victor Electrocardiograph with which absolutely reliable records can be made. Another publication, No. 284 by the same company is entitled, "Industrial Application of the X-Ray." General Electric X-Ray Corporation, 2012 Jackson Boulevard, Chicago, Ill.

106 Microscope Illuminator. An 8 page booklet describing an illuminating device for microscopes producing annular, cross fire, and indirect illumination. Superior Microscope Illuminator Co. 851 Beech Avenue, Pittsburgh, Pa.

107 Air Tools. Catalogue AT 2000 describes and lists prices of air tools of the smallest, fastest and handiest tools. Madison-Kipp Corporation, Madison, Wis.

108 Capacitors. Bulletin GEA-771D describes capacitors for power-factor correction. General Electric Company, Schenectady, N. Y.

INSTRUMENTS, 3619 Forbes St., Pittsburgh, Pa.

Please have me supplied with a copy of each piece of Manufacturers' Literature listed below.

.....

.....

Name.....

Position.....

Firm.....

Street and No.....

City..... State.....

INSTRUMENTS BOOK SHELF

The books reviewed in this section can be supplied by the Instruments Publishing Company.

High Frequency Alternating Currents. *K. McIlwain & J. C. Brainerd.* John Wiley & Sons, Inc., 1931. New York. Cloth, 6x9¼ inches, 510 pages. Price $6.00.

This book is notable in its field because it definitely recognizes electrical communication engineering as a basic and established member in the category of engineering arts. Radio has long been acknowledged a special field of engineering, and in recent years sound has come into its own as a distinct field of applied physics. But the logical combination of the two into the art of electrical communication engineering is, to the knowledge of the reviewer, fully carried out only in this book.

It does this first by choosing for its range of material all that pertains to communication by electricity. Secondly, the different phases of communication are treated by the methods of engineering practice—which means rigid mathematical analysis and precise measurement.

This treatment of the subject matter of course requires in the student a knowledge of the calculus, elementary alternating current theory, and the use of complex numbers. But those who are interested in electrical communication as a field of engineering acquire these subjects are necessary fundamentals anyhow, so that this mode of treatment only makes the book more useful to them.

To be more specific, the authors have combined in one volume various subjects which are usually found scattered throughout the technical literature, such as coupled circuits, thermionic vacuum tubes, amplifiers, modulation, detection, production of high frequency currents, electric wave filters, transmission lines, electromagnetic waves and their propagation, and electromechanical systems. A thorough mathematical analysis is made of each of these subjects, and the appropriate methods of measurement presented.

A list of references is given at the end of each chapter. Some of the material used in the text was taken from these. This enables the student to make a more comprehensive study of the subject by consulting the references.

A liberal amount of problems are given throughout the text, thus allowing the student an opportunity of testing his knowledge, and—above all—to cultivate, by practice, the field of electrical communication as an engineering art.—N. Nazar.

Measurement Practice. (Werkstattbücher, Heft 2, Messtechnik.) By Max Kurrein. Verlag Julius Springer, Berlin, 1932. Paper 6¼x9 in. 78 pages; 160 figures. Price 2RM.

The fact that a third printing has been just issued of this little volume shows that it certainly fills the needs of the operating engineer, foreman, and those who have to deal with machine-shop measurements of any kind. Although without much mathematics, the theoretical fundamentals are set forth clearly and simply and the relation of the units of our measuring system to the absolute units and prototypes is explained. The errors which attend each measurement, personal errors as well as instrumental errors are properly discussed in their connection with accuracy and sensitivity before the actual treatment of measuring technique is given. The tools used, influence of wear, the indirect methods where direct measurements are not possible, are interestingly explained. Mechanical and optical gages in their many forms are fully described. In the last chapter, special measuring methods

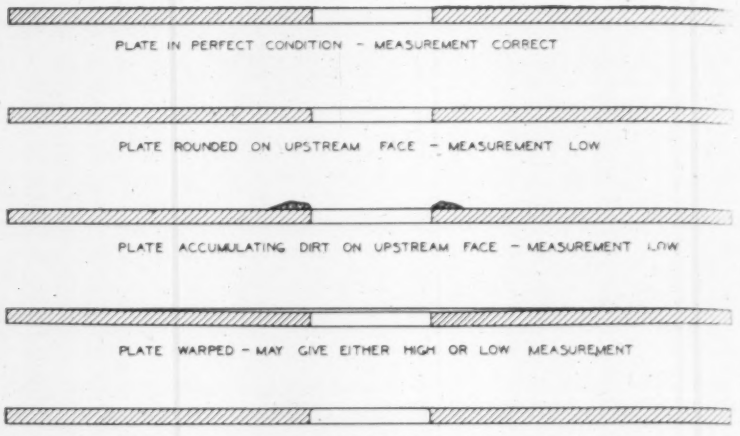


PLATE IN PERFECT CONDITION - MEASUREMENT CORRECT
PLATE ROUNDED ON UPSTREAM FACE - MEASUREMENT LOW
PLATE ACCUMULATING DIRT ON UPSTREAM FACE - MEASUREMENT LOW
PLATE WARPED - MAY GIVE EITHER HIGH OR LOW MEASUREMENT
PLATE WITH WIRE EDGE ON UPSTREAM FACE - MAY GIVE EITHER HIGH OR LOW MEASUREMENT

Fig. 25-24

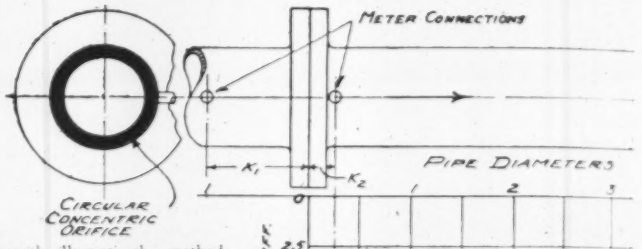


Fig. 25-25

The three cuts herewith illustrate the method used for changing the location of the vena contracta by modifying the design of the orifice plate from the circular concentric type. In the case of the concentric orifice, the location of the outlet connection gradually approaches the orifice plate as the ratio of orifice diameter to pipe diameter increases so that it is often difficult and frequently quite impossible to locate this connection at the vena contracta, especially in the case of Van Stone flanges. Fig. 25-25 illustrates an 80 percent diameter ratio concentric orifice and the pressure differences to correspond. It is noted that the vena contracta is at the point where the pressure connection just clears the flange, as shown, but could not be used if screwed or Van Stone flanges were used. The two lower diagrams show the same relations for eccentric and segmental orifices of the same capacity respectively. Both of these cause the maximum differential pressure to occur at a convenient point for drilling and tapping the pipe clear of the flanges. The three diagrams herewith, and Fig. 25-1 in Sec. 1, show practically the same

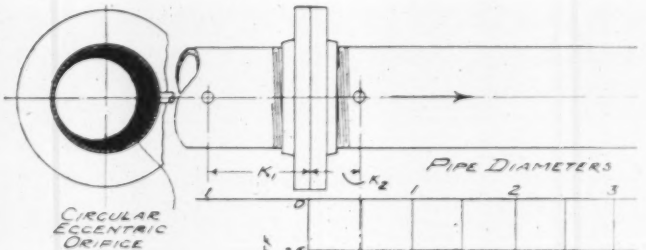


Fig. 25-26

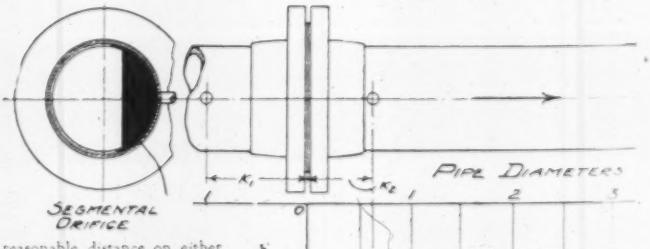


Fig. 25-27

differential head for a reasonable distance on either side of the vena contracta, hence extreme accuracy in locating the meter connections is not necessary. In addition to increasing the outlet connection distance, eccentric and segmental orifices are applied to installations where the fluid contains foreign matter or sediment. The orifice hole is made tangent to the bottom of the pipe, thus preventing foreign matter from lodging at the orifice inlet and thereby insuring accurate metering.—*Adapted from explanation by Bailey Meter Co.*

The orifice devices of a number of makes will now be described—mostly by means of illustrations. Of these, Figs. 25-25 to 25-28 show orifice devices calling for pipe taps and all others show devices not requiring drilling the pipes either above or below. Note, however, that the first four cuts show no "pipe connections," all being "throat connections," while the remaining illustrations (Figs. 25-30 to 25-49) include three distinct sub-types: "throat connections," flange connections" and "integral connections."

The Bailey orifice plates, Figs. 25-25 to 27, have features shown better under "Installations," (Figs. 25-70 and 71). Every plate has a tab bearing serial-number, pressure connection locations, etc. The portion of the plate that comes between flanges is corrugated to form its own gasket. Plates more than 1/32 in. thick are so beveled that the effective thickness at the orifice is 1/32 in. This company also constructs segmental orifices of Monel or other sheets which are fastened inside very large mains without requiring flanges.

The trend seems to be toward orifice devices in which two things are accomplished: (1) avoiding the possibility of errors due to faulty pressure holes in pipes—rough edges, etc., difficult to inspect; and (2) assuring exact distances above and below the orifice plate.

The simplest solution is to supply (not necessarily to ship) two carefully drilled pipe sections (and flanges and gaskets) with each orifice plate. This is seldom done and some meter users who wanted it done declared later, we are informed, that they might as well have purchased a short Venturi. Next (and better) is to supply "flow units" or assemblies in which the *downstream* connection (the important one) is provided. Fig. 25-28 happens to be such a flow unit but this particular assembly, the Republic Flow Meters Co.'s "hat orifice," is especially designed for cases where a plate orifice has to be located at the inlet of a globe valve, an elbow or a tee where there is not sufficient room for the low pressure tap on the downstream side of the orifice. The drawing shows how this particular problem is solved. Another Republic device, Fig. 25-29, is especially designed to provide an exact location for the low-pressure tap, which is located in a filler that also positions the orifice plate. Note that this plate is

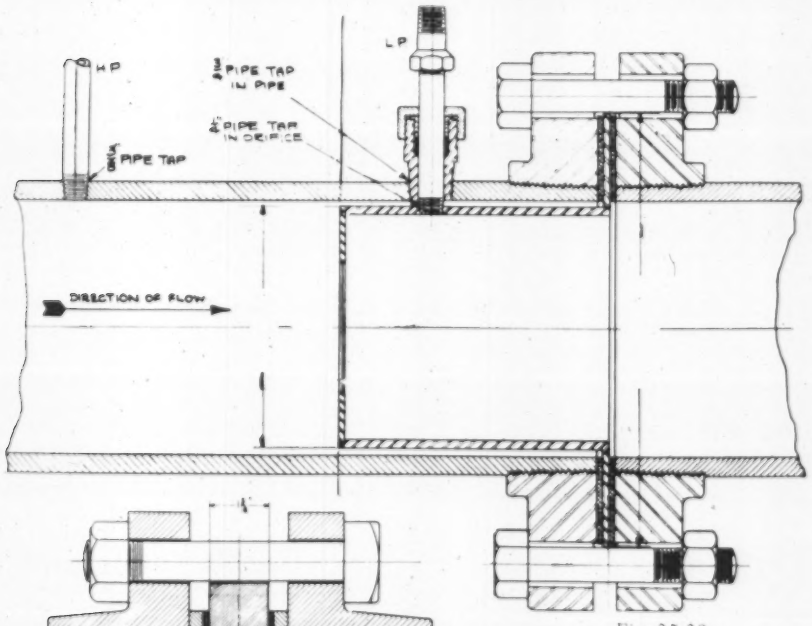


Fig. 25-28

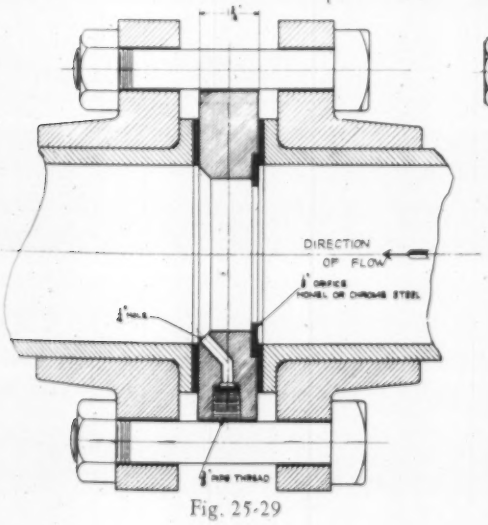


Fig. 25-29

ods are treated, measurements of cones, the determination of angles, measuring of angles with levels (water or spirit) and particularly the measurement of threads. This latter and the tools for it are very exhaustively treated, and a few types of thread measuring machines are described. The book is profusely illustrated with sketches showing the various methods, with photographs of tools and instruments of the best makers of all countries, and diagrams explaining better than long wordy descriptions can how to make a measurement. The high degree of accuracy demanded nowadays in exchange of parts made by different manufacturers can be obtained only by the high standard of our measuring tools. The volume gives an adequate impression of the importance of this fundamental field of our industrial activity where accuracies are sometimes required which come very close to those generally supposed to be applied in laboratories only.

The print and make-up of the book made reading agreeable.—Max Hartenheim.

Air Navigation. P. V. H. Weems. McGraw-Hill Book Company, Inc., New York, 1931. Cloth, 5¾x9 in., 589 pages, 276 figures, bibliography and an index. Price $5.00.

Lieut. Com. Weems, U.S.N., has entitled his book "Air-Navigation" but in the beginning states his preference for, and throughout the volume uses, the term avigation. It is a curious coincidence that Bradley Jones in his volume on "Avigation" reviewed in these columns a few months ago has in general adopted the reverse procedure. An interchange of titles seems indicated. The reviewer takes this occasion to state again his prejudice against the word "avigation."

The methods, instruments, and apparatus relative to the navigation of aircraft are described and discussed almost entirely from the viewpoint of the navigator or pilot. An exceptional number of examples of the procedure to be followed by the navigator are given. The book contains 29 chapters. Three chapters (40 pages) are devoted to a discussion of the use of maps, one long chapter to magnetic compasses and a short chapter to earth inductor compasses. The subject of airways is considered in one chapter and a survey of dead reckoning methods, instruments and tables, together with illustrated examples is given in four chapters (125 pages). The single chapter (35 pages) on radio aids appears to be somewhat inadequate in treatment. The author's enthusiasm for, and well known skill in, celestial navigation are in evidence in all of the eleven chapters (190 pages) covering this subject. Two well written and coordinated chapters on aerology cover 55 pages; one is descriptive in nature and the other relates in general to methods of weather prediction. A final chapter of 25 pages gives the details and data of the navigation of the airplane America in the flight from Chicago to Frederikshaab, Greenland. A bibliography and a good index are appended.

In the chapter on the practice of dead reckoning the author has stated with great clarity the limitations and interdependence of the various branches of air navigation which are defined as piloting, dead reckoning, radio, and celestial navigation. The definition of the word "piloting" is given as "the method of directing aircraft from place to place by referring to visible landmarks on the land's surface." It should be remarked that the first six pages of this chapter (XIII) should undoubtedly be read before reading the chapter (XI) on dead reckoning instruments in order to obtain the proper perspective.

The chapter on dead reckoning instruments leaves a great deal to be desired in the way of the treatment and choice of the material. For example, the altimeter shown in Fig. 9 is an obsolescent Navy instrument both as to mechanism and dial. For this reason the description of altimeter troubles and their remedies are in many cases of little value. Thus, since nonferrous hair springs are now used in all altimeters and the mechanism with the chain is not now used, reference to the rusting of these parts is superfluous.

Further, it is unfortunate that the practically obsolete pitot venturi type air speed indicator is described in some detail although the pitot-static type which has been standard in this country for the last six or seven years is given but a casual reference. The inclinometer shown in Fig. 96 is practically obsolescent. The term "recording barograph" which is a redundancy is used in this chapter while in the chapter on Aerology the instrument is properly called a barograph.

It should be noted that the air speeds given in the Dead Reckoning Tables (Nos. I, III, IV, and VII) are not in general the same as the indication of the pitot-static type air-speed indicator usually installed on airplanes. The indications of this instrument must be corrected for the effect of variation in the air density from that assumed as standard in calibrating the indicator. A highly approximate method of making this correction is briefly given on page 168, but in the chapter on the Tables the reader is left to infer by the sentence on page 194, "The air speed is of course taken from the air-speed meter," that the indication of the instrument is sufficient for use in the Tables. The correction for air density is by no means negligible even when flying at low altitudes and its importance warrants the addition of a complete discussion together with charts or tables to aid in its computation.

There is a little looseness in ascribing credit throughout the volume. For example no mention is made on page 479 of the prior work of Bradley Jones in precomputing the altitude of celestial bodies for the Maitland-Hegenberger flight to Hawaii in 1927. Another example is the omission of reference to the work of the General Electric Co. and of Behm in Germany on the echo altimeter which is discussed on page 539.

The section of the book on celestial navigation in particular is full of enlivening references to the author's own work and personal experiences. This adds greatly to the reader's interest and the charm of the book, although it does lead at times to a somewhat unbalanced treatment. The methods and instruments preferred by the author in celestial navigation are on the whole on solid ground and have stood the test of practice, but it must not be inferred that these methods are final. The art is in a state of flux at the present time with the experts in the field far from united on a given method.

Of the number of books recently published on air navigation it is the most comprehensive and undoubtedly should be one of the reference books in the possession of every student of the subject. The imperfections are in most cases minor. Evidence of the high quality of the book is the fact that it was chosen by the National Aeronautic Association as the United States entry in the competition held by the Aero Club of France for the outstanding aeronautic book in any foreign language in 1931.—W. G. Brombacher.

The Colorimetric and Potentiometric Determination of pH. By I. M. Kolthoff. John Wiley & Sons, Inc., 1931. Cloth, 9¼x6 in. 167 pages. Price $2.25.

While this fourth book from the pens of Dr. Kolthoff and his co-authors is not as comprehensive as its name might lead one to believe, it does bridge the gap between the more elementary treatises usually given in books on physical chemistry and the more comprehensive works of Sorenson, Clark and Britton. It has been written as an introduction to the broader field and for the use of the more advanced student. The author's purpose is "to offer enough material to enable the student to apply the important methods to his own specific problem of research."

The theory has been presented in Part I in condensed form, frequent reference being made to the standard books on the subject. Preparation of indication buffer solutions and the colorimetric measurement of pH are also treated in a way to indicate general procedures rather than to give detailed directions.

separable from the filler (otherwise we would have an "integral location" of the downstream tap). This unit permits a large ratio of orifice diameter to pipe diameter for, as this ratio increases, the downstream tap location becomes critical and its proper distance so small that it cannot always be obtained when standard flanges are used.

Most orifice assemblies on the market, however, embody *both* connections. The thirty remaining illustrations are of such devices with "throat connections" (Figs. 25-30 and 25-31), "flange connections" (Figs. 25-32 to 25-44) and "integral connections" (Figs. 25-46 to 25-49). First, an assembly that includes pipe sections. In this Brown Instrument Co. flow unit (Figs. 25-30) for pipe sizes up to 3 in., a block holds the orifice plate in the proper position and contains

Fig. 25-30

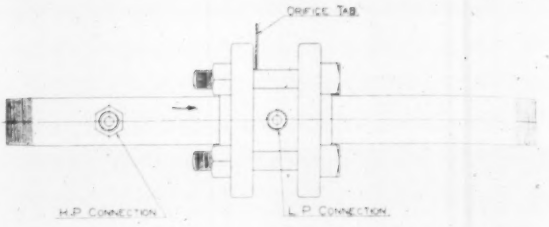
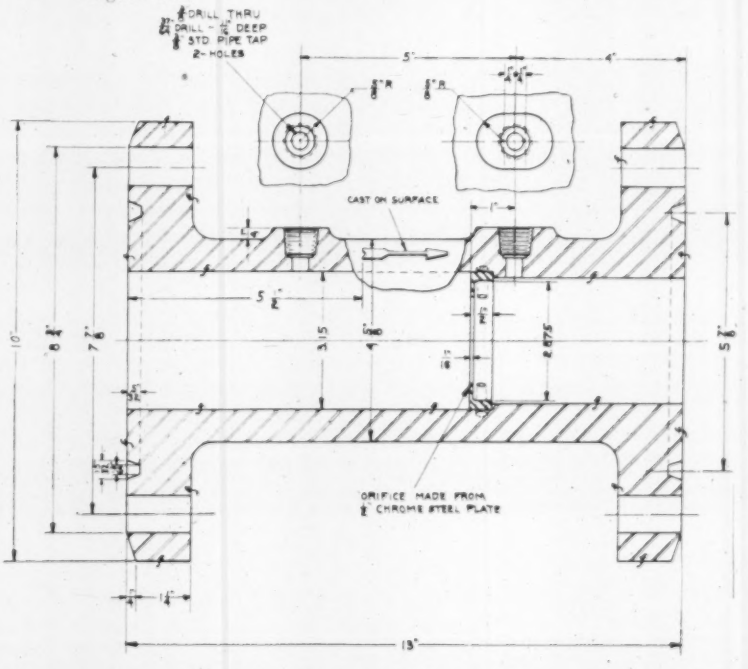


Fig. 25-31



the downstream tap. Next is a unit (Fig. 25-31) supplied by the Republic Flow Meters Co. for high-pressure work—600 lb. or more—where there often is an objection to tapping the pipe because of the expense and inconvenience of welding bosses (apart from possibility of improperly located or finished holes). The manufacturer writes us, " . . . we can guarantee accuracy because, since the parts are machined here at our factory, we are sure of the ratio of upstream section diameter to orifice diameter, as well as of the tap locations. This scheme, I believe, is going to be used rather generally in the future where very accurate results are required."

Flange Connection Assemblies.

Easy changing of orifice plates is obtained with most makes of flange connection orifice assemblies. Fig. 25-32 shows the parts supplied by the Metric Metal Works of the American Meter Co. and Fig. 25-33 shows how the jack-screws are used to spread flanges apart when removing and replacing the "Westcott" orifice plates. These plates are machined from cold rolled steel (or other materials) to a tolerance of 0.001 in., the edge is honed after machining and "a record of every disk is kept by us for further reference." In Fig. 25-34 which shows the parts of the Pittsburgh Equitable Meter Co.'s assembly, note the "A.G.A. Committee distances" (see extracts from report in Sec. 11) for tap locations. The "Emco" orifices are of thicknesses increasing with pipe size, beveled to leave edges not more than ⅛ in. thick. Tabs bear data on size, etc. Fig. 25-35 shows an assembly in use. The inside surface of each flange the

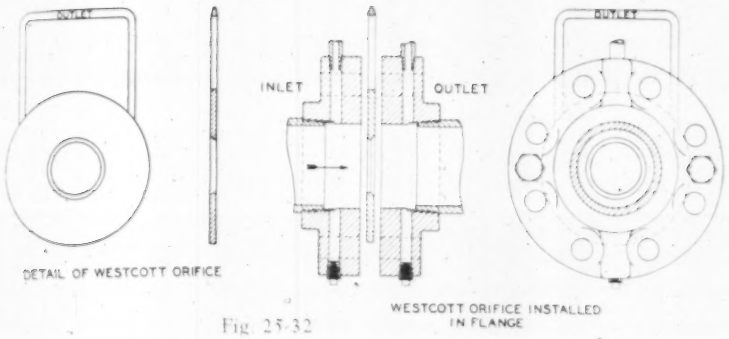


Fig. 25-32

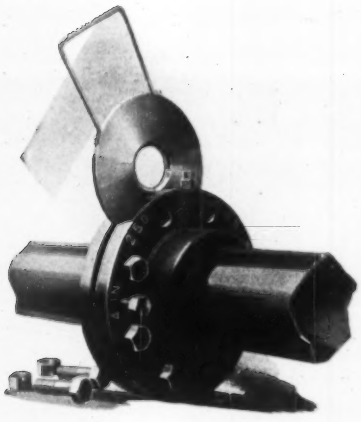


Fig. 25-33

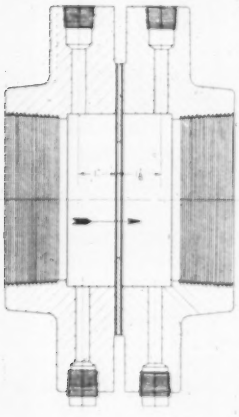


Fig. 25-34

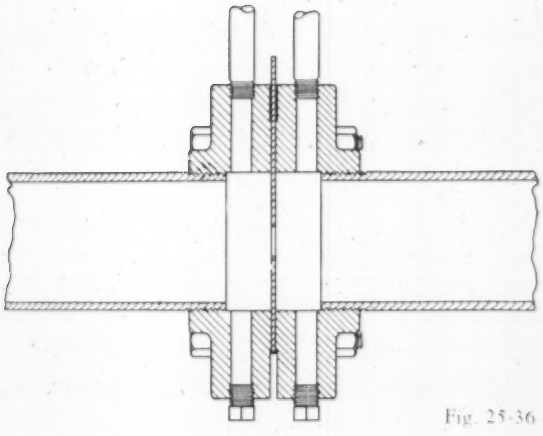


Fig. 25-36

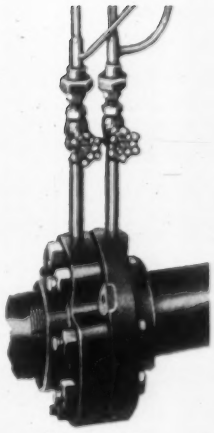


Fig. 25-35

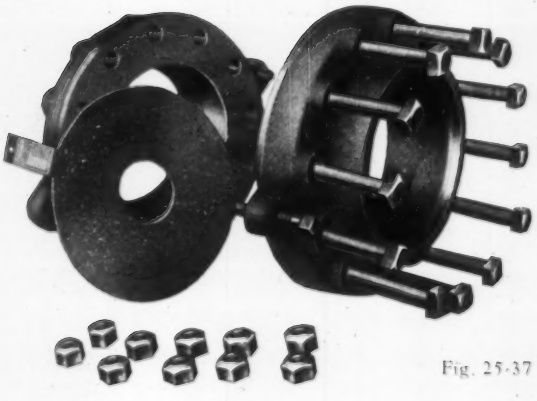


Fig. 25-37

Part II of the book treats of the potentiometric determinations of pH and includes descriptions, of the types of apparatus and instruments to be used in both the potentiometric and the thermionic valve methods. The chapter on the various types of electrodes whets one's appetite for more detailed information, particularly so in view of the author's own extensive work along these lines.

The last part deals with conductometric titrations and their time saving applications to chemical analysis. An outline of a practical course covering the fundamental subjects covered in the book is appended.

Lists of problems follow the chapters while numerous convenient tables of data are given throughout the book.

While the book was written for student use, it contains much of both theoretical and practical value to those who use hydrogen ion concentration as a medium of control in research and plant production. The book will be particularly welcomed by those older chemists who feel they need an occasional brushing up on the newer trends in chemistry and yet who do not have the time to delve into the more encyclopedic works.—Arthur Schroder.

• • •

INSTRUMENTS EMPLOYMENT SERVICE

No charge for insertion of notices, which should be addressed to INSTRUMENTS Employment Service, 3619 Forbes Street, Pittsburgh, Pa., should be written tersely and must be received by the 25th of the month. In replying, put identification number on both envelope and letter.

MEN AVAILABLE

INSTRUMENT MAKER: 3½ years experimental laboratory of lamp company; 2 years experimental laboratory of electrical company. J-2.

PYROMETER MAN: Graduate Pennsylvania State College. Had charge of pyrometer calibration laboratory in plant with 1100 pyrometers. J-3.

ELECTRICAL ENGINEER: Graduate Charlottenburg Technische Hochschule; 8 years research engineer with chemical company; 4 years steel plant electrical engineer; can read German, French, Spanish and Italian. J-6.

INSTRUMENT SALESMAN: Mechanican Engineering Graduate; experienced sales and service most type of power plant instruments. District Sales Manager 5 years. Experience on gages, flow meter, CO_2 recorders, pyrometers and other testing equipment. J-8.

PYROMETER MAN: 8 years experience; expert electrician and gage (hydraulic, pressure, vacuum, etc.) service man; 3 years instrument laboratory; education equivalent two years of engineering college. J-9.

INSTRUMENT ENGINEER: Graduate Engineering College. Charge of instrument department in large industrial plant for 2½ years. J-10.

RADIO OPERATOR: Graduate Dodge Institute, 1917. Commercial license either broadcast or telegraph. J-12.

INSTRUMENT SALESMAN: Graduate M.E., 4 years control instruments, 2 years power plant specialties, 4 years manufacturing experience, in shop. Now N. Y. District Mgr. large rolling mill. J-13.

PHYSICIST: Ph.D. 1927. Experienced in electric and magnetic measurements, testing and research. J-14.

PRECISION INSTRUMENT MAKER: 28 years experience on scientific and geophysical instruments. J-15.

RADIO ENGINEER: Graduate University of Illinois; 2½ years experience in radio set circuit and tube measurements as well as development, design and patent investigation work. J-16.

ELECTRICAL METER and INSTRUMENT MAN: Technical graduate, 8 years in instrument laboratory of electrical manufacturing company. J-17.

INSTRUMENT ENGINEER: 2 years university, 5 years public utility, 2 years sales and service large recording and controlling instrument manufacturer. J-18.

INSTRUMENT MAKER: Engineering and Drafting instruments, 20 years shop experience. Master Degree Guild of Nuremburg. J-19.

ELECTRICAL ENGINEER: Graduate Purdue University. Experience with Telephone and Telegraph circuits, industrial control methods and equipment, and electrical instrument testing and maintenance. J-20.

AIRCRAFT INSTRUMENT MAINTENANCE ENGINEER: Formerly Service Engineer for largest manufacturer of aircraft instruments. Especially familiar with airplane instrument problems. J-21.

CHEMIST: Graduate Hunter College 1918. Spent twelve years working out various chemical processes in the laboratory and demonstrating them from a practical standpoint in paper mills. Work in the laboratory has included water analyses, some bacteriological work, fibre examination, and testing of various material. J-22.

ADVERTISING MANAGER: Also assistant sales manager of flow meter manufacturing company; available March 1. M.I.T. graduate Mechanical Engineer with 10 years shop, engineering, advertising and sales experience. J-23.

PHYSICIST: 2 years experience in research with particular training in atomics and electronics. Have held two fellowships. J-24.

COMMUNICATION ENGINEER: 10 years practical experience in installation, operation and maintenance of high frequency transmitters and receivers, also land line practice. Knowledge of Spanish. J-25.

ELECTRICAL ENGINEER: Experience with electric meter manufacturer and with an electrical testing laboratory. Master's degree in electrical engineering. J-26.

SALES ENGINEER: Sales promotion work on scientific instruments, industrial control, etc. Three years experience with manufacturer of scientific instruments and three years experience with manufacturer of automatic regulating devices. Graduate of University of Chicago. J-27.

Professional Cards in
INSTRUMENTS
(Including Copy of Paper)
$7.50 per month

Professional Cards in
INSTRUMENTS
(Including Copy of Paper)
$7.50 per month

tween thread and face) is machined to exact diameter. The "Emco" line is for gas work only. The Foxboro Co.'s device is shown in Figs. 25-36 and 37. The manufacturing tolerance for Foxboro orifice diameters is "0.0005 of an inch per inch."

Still closer to the orifice plates are the connections in the devices reviewed in this paragraph. Special flanges supplied by the Republic Flow Meters Co. for pipe lines under 3 in. are shown in Fig. 25-38 which requires no further explanation. A Los Angeles Manufacturer, Morey & Jones, Ltd., supplies the

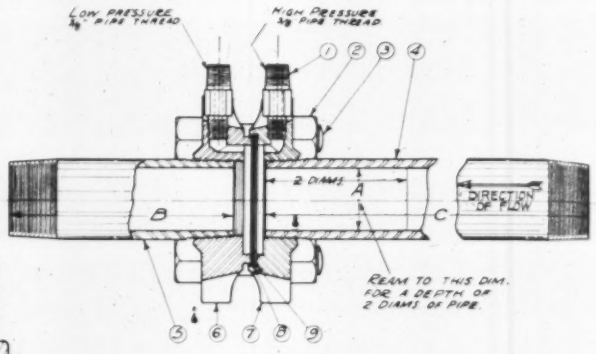


Fig. 25-38

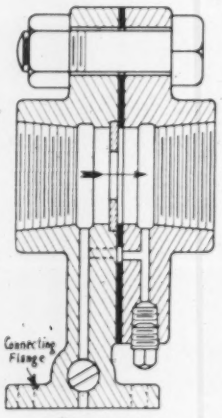


Fig. 25-39

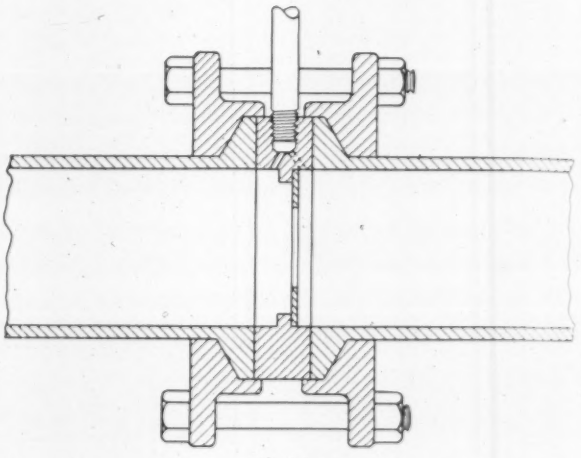


Fig. 25-40

Fig. 25-41

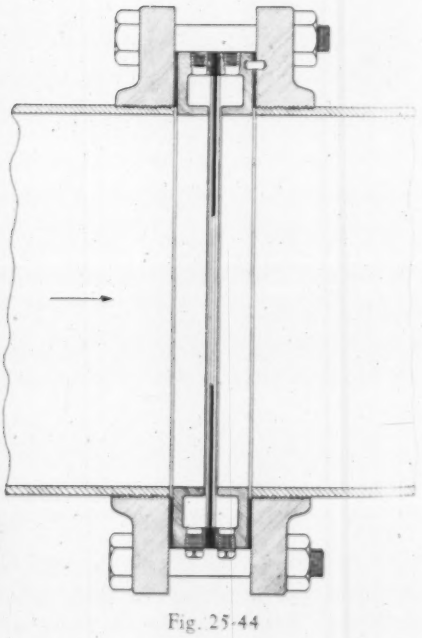


Fig. 25-44

Fig. 25-42

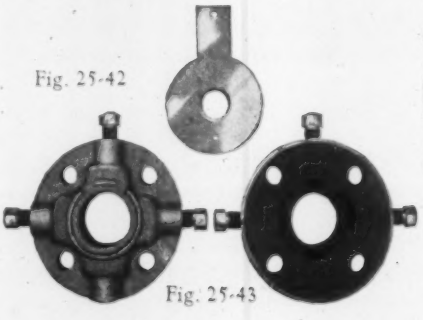


Fig. 25-43

ingenious "Close Hook-up" flange unit, Fig. 25-39, in which the downstream connection passes through a special gasket to the upstream flange which is provided with a small connecting flange to which is fastened an indicating manometer (described in Sec. 13). The two passages in this flange are lined up (perpendicular to the plane of the drawing) and can be cut off simultaneously by means of a plug valve. As with a previously-mentioned device, the Foxboro Co.'s "holding ring" positions the orifice plate but it contains both instead of one connection, as Fig. 25-40 shows. The ring itself is shown in Fig. 25-41. The connections are welded. Annular chambers are formed in the flanges of the next two assemblies, the "Oriflo" of Builders Iron Foundry, Figs. 25-42, 43; and that of the Bacharach Industrial Instrument Co., Fig. 25-44. These chambers extend approximately three-quarters of the circumference in "Oriflo" flanges, all the way around in Bacharach flanges. "Oriflo" flanges are suitable for pressures up to 250 lb.; the Bacharach assembly illustrated is designed for low-pressure air and gas metering. Orifice devices such as the "Oriflo" or Bacharach, having ample size pressure passages, minimize instrument lag and are therefore useful on "lively" lines.

"Integral connections" are provided in the Cochrane Corp.'s orifice plates, Figs. 25-45 to 25-49. The regular plate is ¼-in. Monel, 45° bevel to narrow

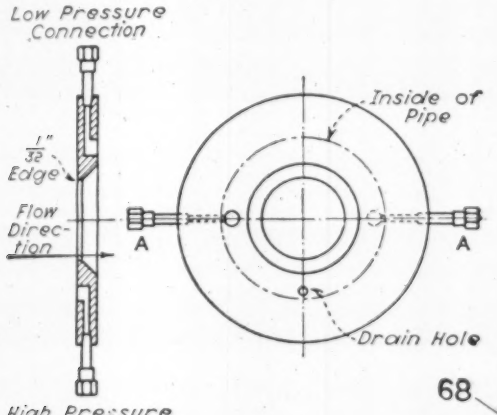


Fig. 25-45

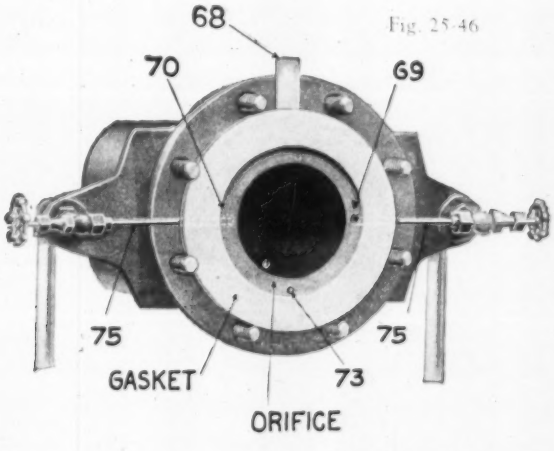


Fig. 25-46

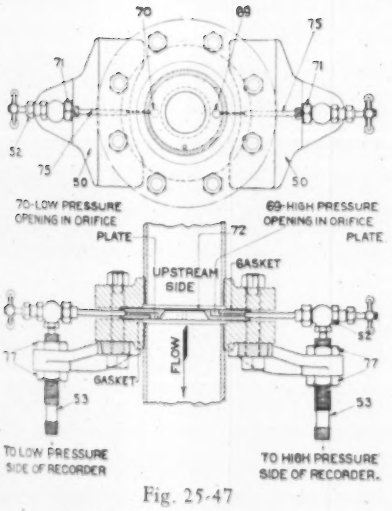


Fig. 25-47

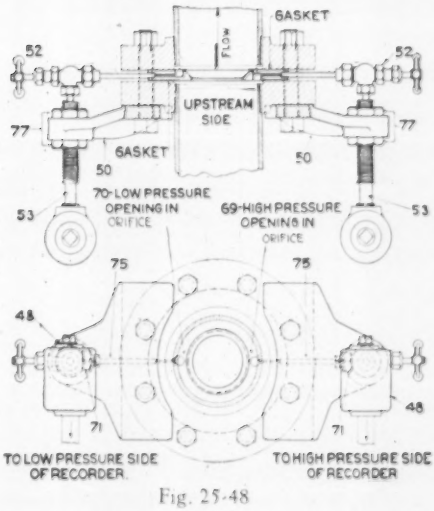
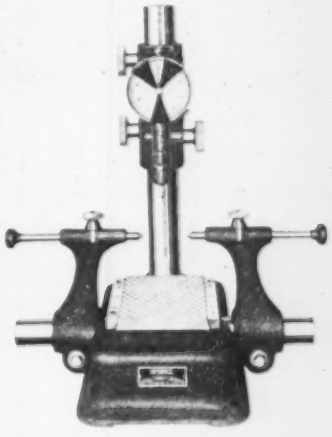


Fig. 25-48

FEDERAL

PRECISION MEASURING INSTRUMENTS AND DIAL INDICATORS



FEDERAL PRODUCTS CORP.
PROVIDENCE, R. I.
CHICAGO · CLEVELAND · DETROIT
NEW YORK · MUNCIE, IND.

AMERICAN
Chain-Poise Variable-Weight Analytical Balances
200 Grams Capacity
From $125.00 Plain or with Keyboard Weight-Manipulator With Weights

AMERICAN
Chain-Poise Variable-Weight Micro-Chemical Balances
25 Grams Capacity
1-100 to 1-1000 mg Sensitivities
From $150.00 Plain or With Keyboard Weight Manipulator With Weights

Rider Analyt. Balances
200 Grams Capacity
From $80.00 Plain or with Keyboard Weight Manipulator With Weights

Rider Micro-Chemical Balances
25 Grams Capacity
1-100 to 1-1000 mg Sensitivities
From $125.00 Plain or with Keyboard Weight Manipulator With Weights

Assay-Balances
1-100 to 1-1000 mg Sensitivities
From $125.00 Plain or with Keyboard Weight Manipulator With Weights and Mechanical Pan Extractor

THOUSANDS IN DAILY USE

All-Metal Construction
Unaffected by Climatic Conditions

The HEUSSER INSTRUMENT MFG. CO.
SALT LAKE CITY, UTAH.

Books for Your Library

Allen The Principles and Practice of Electrical Testing

As applied to Apparatus, Circuits, and Machines. By R. G. Allen, Assistant to the Professor of Electrical Engineering and Teacher of Electrical Machine Design, Royal College of Science for Ireland. 365 pages. $4.20

Campbell An Account of the Principles of Measurement and Calculation

By Norman Robert Campbell, Member of the Research Staff of the General Electric Co., Ltd., Wembley. 302 pages. $5.00

Grant The Measurement of Hydrogen Ion Concentration

By Julius Grant (London). 165 pages. $3.75

Henley The Inspection and Testing of Materials, Apparatus and Lines

By F. L. Henley, Staff Engineer, General Post Office. 355 pages. $7.00

Ibbotson and Aitchison The Analysis of Non-Ferrous Alloys

By Fred Ibbotson and Leslie Aitchison. 238 pages. $4.50

Kaye High Vacua

By G. W. C. Kaye. 187 pages. $3.75

Knecht and Hibbert New Reduction Methods in Volumetric Analysis

By Edmund Knecht, Professor of Technological Chemistry, Victoria University of Manchester, and Head of the Chemical Department, Municipal School of Technology, Manchester; and Eva Hibbert, Demonstrator in Chemistry, Municipal School of Technology, Manchester. 118 pages. $3.00

Lyman The Spectroscopy of the Extreme Ultra-Violet

By Theodore Lyman, Hollis Professor of Natural Philosophy, Emeritus, in Harvard University. *New edition, largely rewritten and brought up to date.* 167 pages. $3.75

Palmer Wireless Principles and Practice

By L. S. Palmer, Head of the Department of Pure and Applied Physics in the Faculty of Technology of the Victoria University, Manchester. 518 pages. $7.00

Pannell The Measurement of Fluid Velocity and Pressure

By J. R. Pannell, of the National Physical Laboratory. 148 pages. $4.00

Smith Analytical Processes

By T. B. Smith, Assistant Lecturer in Chemistry, University of Sheffield. 381 pages. $5.00

Tuttle and Satterly Theory of Measurement

By Lucius Tuttle, formerly Associate in Physics, Jefferson Medical College, Philadelphia, and John Satterly, Professor of Physics, University of Toronto. 345 pages. $4.50

Wallis Analytical Microscopy: Its Aims and Methods

By T. E. Wallis, Lecturer in Botany to the Pharmaceutical Society of Great Britain. 150 pages. $2.25

Send Orders to

Instruments Publishing Company

3619 Forbes Street, Pittsburgh, Pa.

orifice edge, plates cut to fit inside bolts of existing flanges. The parts supplied are shown numbered in the last three figures. This set of five illustrations pertaining to one design of orifice plate brings out interesting points as will be taken up below under "Installations."

Quick-change Devices

To conclude this review of orifice devices, mention may be made of special designs which permit changing orifices with little interruption in the flow of fluid—or with no interruption at all of the flow.

The design we should like to see has not yet appeared on the market. It would be an *infinitely variable concentric circular* orifice, and would probably work along the lines of the iris diaphragm used in photography. It would of course preclude throat connections accurately located for all openings since the vena contracta approaches the plane of the orifice as the diameter ratio increases. Either close or pipe connections, however, would work out satisfactorily and curves could be plotted fairly accurately for the values of the coefficients although the orifice would not be a true circle. In addition to the iris diaphragm we find three other principal forms used in cameras: the long slide with holes of several sizes any one of which may be lined up, the rotatable disk with several sizes of holes, and the arrangement whereby one rectangular plate can be lifted up and another slid down guides into place.

For fluid metering there seems to be no "long slide" multiple orifice on the market, but we find the turning-disk idea realized in a practical multiple-orifice fitting brought out (so far for very small pipes only) by the Meriam Co. This fitting forms part of an indicating manometer described in Section 13. Flow is interrupted, of course, while the plate is being rotated. The Robinson Orifice Fitting (Robinson Orifice Fitting Co. and Foxboro Co.) is a device which

1. Top cover
2. Upper chamber
3. Grease groove
4. Packing gland
5. Taper plug
6. Collar packing gland
7. Screws
8. Packing
9. Collar studs
11. Bottom plate
12. Elevator arm
13. Packing nut
14. Elevator screw
15. Elevator screw protector
16. Relief valve
17. Grease gun for lubricating plug
18. Orifice plate rod
19. Packing gland
20. Packing
21. Jackscrew (turn to right to loosen plug, turn to left to repack)
22. Packing gland collar
23. Orifice plate
24. Orifice plate guide
25. Drain holes

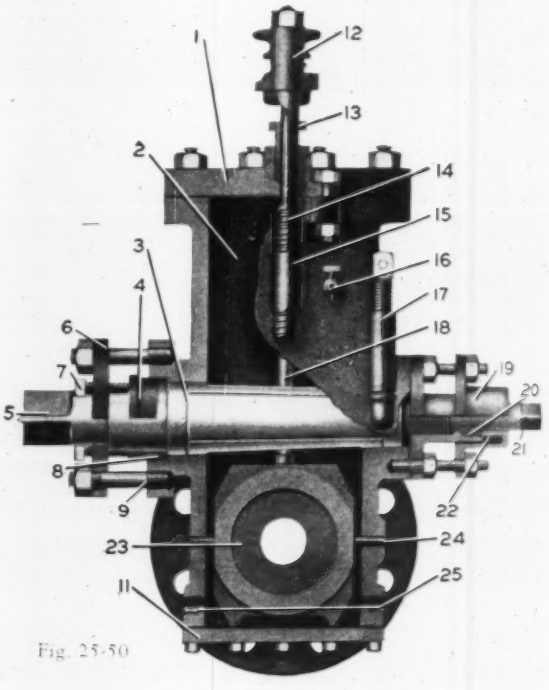


Fig. 25-50

makes it possible to change plates in larger industrial sizes of pipes, and without any interruption of fluid flow. It employs the slide guide idea, and is made up in various designs for pressures up to 500 lb. Fig. 25-50 shows an inside view, and the operation is explained in the following extracts:

The Robinson Orifice Fitting simplifies the method of changing or inspecting an orifice meter plate and reduces the expense and inconvenience of a by-pass. During the short time taken to inspect the plate the flow of the fluid is not interrupted, and there is no hazard. There is no chance of stopping the flow, nor is there any danger of breaking the orifice flanges. The Robinson Fitting aids in accurate measurement, since it accurately centers the orifice. It eliminates the by-pass with its accompanying valves, tees, and ells. The fitting occupies no more space than an ordinary gate valve and can be mounted in almost any position.

To Change Orifice Plate. Tighten jackscrew (21) to loosen plug (5); turn plug (5) until indicator on plug (5) shows open. Loosen set screws on outside of body (not shown in illustration) to release orifice plate (23) from seat. Screw orifice plate rod (18) into orifice plate. Turn elevator screw (14) to lift orifice plate into upper chamber (2). Turn plug (5) until indicator on plug (5) shows closed. *Open relief valve* (16). Swing elevator arm (12) away from orifice plate rod (18). Remove top cover (1) and change orifice plate.

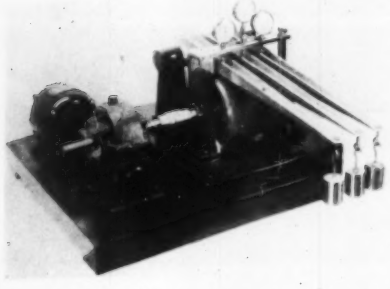
Reverse operations to replace orifice plate.

Rubber Abrasive Resistance Tester

American Instrument Company

THIS device is a machine intended to reproduce in the laboratory, in a relatively short time, the conditions of wear on rubber that may be expected in normal use of the rubber over a long period of time.

The constants of the machine are such that the wear period is long enough to allow close comparison between specimens without unduly lengthening the test.



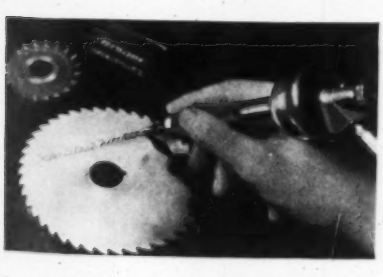
The machine consists essentially of a drum 6 in. in diameter covered with standard garnet paper held in place by heavy elastic rubber bands. The drum is driven by a ¼ h. p. motor a. c. or d. c. through a 40:1 speed reducer. Three independent levers, each weighted at their unsupported ends, carry on their under surfaces the test specimens. These are 1 in. square x ¼ in. thick and three specimens can be tested simultaneously. The speed of the machine is substantially constant and the revolutions are counted by a Veeder counter attached to the drum axis but not shown in the photograph. The counter may be reset to zero after each test. The wear on each specimen is measured by a dial gage readable to 1/1000 in. The weight of the lever arm is so adjusted that a pressure of exactly 5 lbs. is exerted on the specimen. The garnet paper used is of standard manufacture, and therefore readily obtainable.

◆ ◆ ◆

Steel Writer

Madison-Kipp Corporation

THIS device is essentially a high-speed (40,000 r. p. m.) hand grinder. Due to its high speed, it grinds the surface of metals and glass almost as



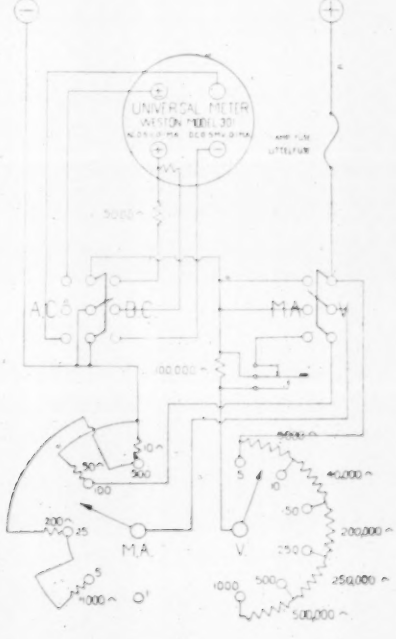
fast, it is claimed, as one can write. This makes it a handy device for marking laboratory and tool room equipment.

Multi-Range Voltmeter and Milliammeter

Shallcross Mfg. Company

BOTH a voltmeter and a milliammeter for a. c. as well as d. c., with a number of ranges in each case, are provided in this combination instrument.

Essentially it comprises a measuring circuit using a number of the Shallcross company's Akra-Ohm calibrated resistors in conjunction with a universal meter. As the wiring diagram shows, the different ranges for the meter scale are chosen by proper setting of a selector switch.



Change-over from a voltmeter to a milliammeter, or from a. c. to d. c., is effected by the throwing of a switch. All voltage scales are 1000 ohms per volt, making it a useful meter for vacuum tube plate-voltage measurements. The current scales operate on a 5 volt drop. A fuse is provided to protect against burning out the meter.

NEW INSTRUMENTS

Recently Developed by Manufacturers

Write Information Section, Instruments Publishing Company, for additional Information.

Printers' Moisture Indicator

Cambridge Instrument Company, Inc.

PROPER humidity conditions in a pressroom and the right moisture content of the paper used are highly important for good printing. To help the lithographer determine the moisture condition of both pressroom and paper, this instrument was developed.

It is a small, portable device which measures the moisture content of piled or stacked paper as readily as it will indicate the humidity of the air in the pressroom. As seen from the illustration the instrument consists of a light case provided with a pistol grip, to which is attached a thin hollow blade 1 in. wide by 18 in. long, the extreme end of which is perforated on both sides. Within the perforated section of the blade is located a measuring element whose length varies with changes in moisture, and the movement of which causes the indicator pointer to move across the scale. The scale is calibrated in percent relative humidity with a range of 20 to 80%. A manually set index pointer is provided for keeping track of a reference point, such as air humidity, when making comparative readings. This distinctly colored (red) pointer is readily set by means of a knurled screw on the face of the case.

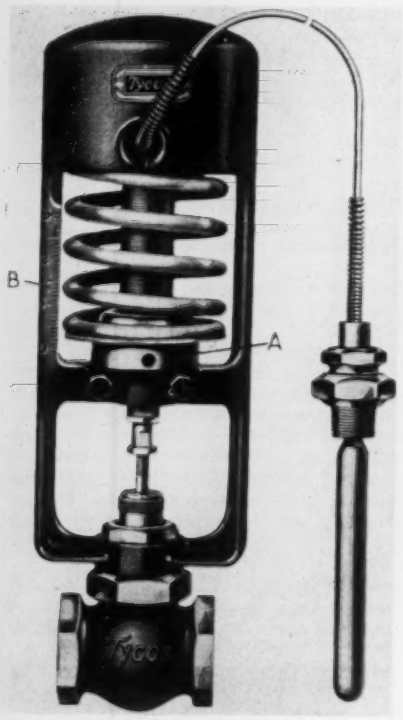
In making a determination of air conditions it is only necessary to expose the instrument to the air for a moment, whereupon the pointer will take a position corresponding to the relative humidity of the air. In making a moisture measurement of paper in stacks the blade is pushed between the sheets to any desired depth, thus allowing the moisture inside the stack to enter the perforated section of the blade and produce a movement of the sensitive element. In the case of moisture variations of the extent normally encountered, a steady reading can be obtained in 15 to 40 seconds.

The scaling of the instrument directly in terms of relative humidity and its ready portability, make it a widely useful instrument for measuring both air humidity and paper moisture.

A New Self-Acting Temperature Regulator

Taylor Instrument Companies

IN ALL self-acting regulators of the direct bellows and stem-connected type, the movement of the valve stem is intended to be proportional to the change in temperature of the bulb. The theoretically perfect action is that the position of the valve should always be the same for a given bulb temperature and should move in direct relation to changes of bulb temperature. In practice, the accomplishment of this ideal is hindered by the element of friction.



Friction seriously interferes with the operation of most regulators of the self-acting type, manifesting itself by the inability of the valve stem to assume the same position for the same bulb temperature. Actually what occurs is that the bulb temperature must be changed several degrees before the valve stem starts to move. This characteristic made close control with this type of regulator difficult, hence limited its field of usefulness.

Obviously during this period when the temperature of the bulb is increasing or decreasing with no resultant stem movement, the disc in the valve does not move and consequently the rate of flow through the valve is not changed. This range can be called the "dead period." In some regulators, it amounts to over 10° F. In the new Tycos regulator it has been reduced until practically eliminated and the stem moves almost simultaneously with the temperature change, giving a throttling control that is very desirable. This practical elimination of friction is a major improvement, contributing to accurate performance.

Another element which contributes greatly to the performance of this regulator is the construction of the tube system. This consists of a double seamless bellows, extra heavy walled copper connection tubing, and stainless steel bulb of exceptionally small size and thin wall.

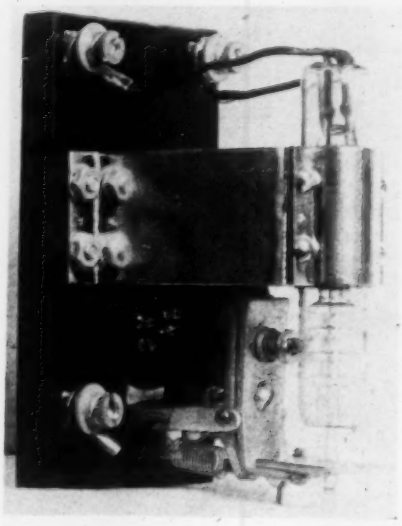
This tube system requires a minimum volume of actuating medium, which makes a small bulb possible and together with the thin wall of the bulb and its shape results in a tube system that responds quickly to temperature changes. Of great value also is the overheating features of the tube system which permits heating the bulb beyond the upper limit of the range of the instrument without injury.

◆ ◆ ◆

Vacuum Contact Midget Relay

Ward Leonard Electric Company

THIS addition to the above company's line of midget relays uses a vacuum contact element actuated by the relay armature. The contact element is rated at 8 amps. intermittently and 6 amps. continuously at 220 volts.



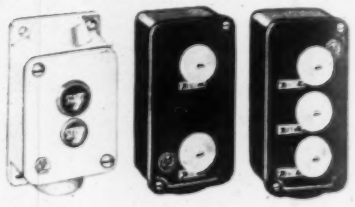
Due to this type of high-rating, enclosed, contact element, these relays are applicable for heavy-duty operation, even in hazardous locations.

Push-Button Stations for Heavy-Duty Service

Allen-Bradley Co.

IN THIS heavy-duty push-button mechanism, for use where heavy currents must be handled or where the push-button duty cycle is very severe, high-capacity is obtained by the use of silver-to-silver contacts and multiple breaks.

The heavy-duty mechanism can be supplied with one, two, or three buttons; it is also available for water-tight or explosion-proof control stations for operation by push-button, hand, foot, rope, or shipper rod.



Any of the heavy-duty push-button stations can be supplied with a safety lock which, when moved over the "stop" button, can be padlocked in place and holds the button in so the motor or control cannot be started from this or any other station.

◆ ◆ ◆

A New Tape-Rule

The Lufkin Rule Co.

THIS instrument is a pocket measuring tape which can also be used as a rule. The 7/16 in. wide blade of this tape, tempered and stiffened by special forming, can be projected unsupported to walls or into openings like a rule. This tape is graduated in inches to 16ths, winds automatically, and is available in two lengths, 4 and 6 ft.

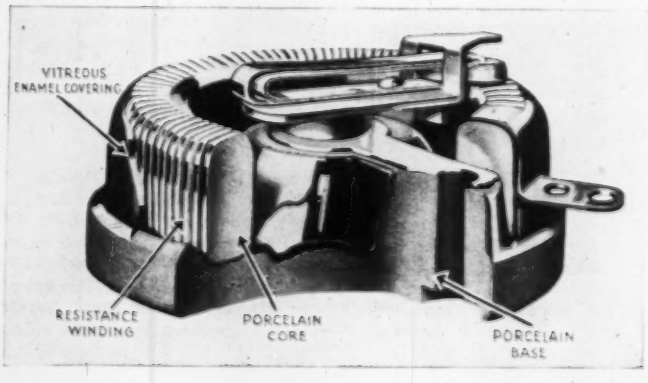
◆ ◆ ◆ ◆ ◆

Enameled Variable Resistors

Ohmite Manufacturing Company

THE illustration shows the details of the Ohmite rheostat construction. The resistance wire is wound around the solid porcelain core in such a way that it is completely insulated and protected by the vitreous enamel covering. With this type of construction it is virtually impossible for the wire ever to become loose or to slide on the core. The enamel, besides insulating the wire, locks it firmly in place.

These rheostats are listed in two sizes, a 50 watt unit and a 150 watt unit, in a complete range of resistance values from 1 ohm up to 35,000 ohms.



Water and Dust Tight A. C. Manual Starter

Square D Company

COMPACT and rugged, this a. c. manual starter of water and dust tight construction is a three pole starter designed to control across-the-line single and polyphase motors of 2 h. p. or less. It is particularly suited to packing plant, creamery, flour mill, and similar applications where extreme moisture and dust conditions are encountered.

In addition to the water and dust tight construction, other outstanding features are push button operation and compactness. Overload protection is provided by time limit overload relays which are front reset and require no replacement of parts after operation. Tripping of either relay opens all three lines. Approximate dimensions are 4¾" wide, 8¾" high and 6" deep.

◆ ◆ ◆

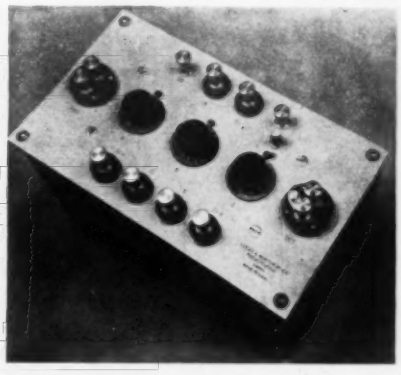
New Shielded Ratio Box For Impedance Bridges

Leeds & Northrup Company

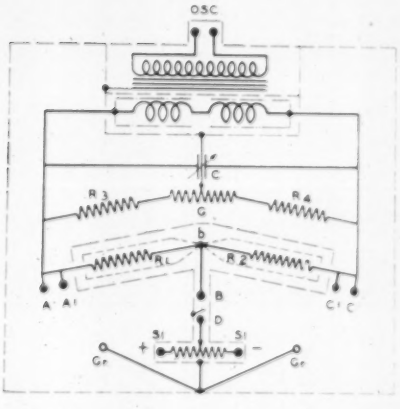
THE Campbell-Shackelton Shielded Ratio Box is a new instrument for high-precision a.c. measurement. It contains all the parts, except the standard and the detector, which are necessary for a one-to-one impedance bridge.

The unique feature of this box is the shielding. In its general plan, this is based on the studies of Messrs. G. A. Campbell, W. F. Shackelton and J. G. Ferguson.[1] The shielding is shown schematically in the diagram. It is so arranged that the instrument may be used either with one point grounded, or with a Wagner earth connection.

The Ratio Box is designed for use at frequencies of 50 to 50,000 cycles per second. An input potential of 30 volts at 60 cycles may be used under average conditions. The limit of error is either 0.01%, 0.01 ohm (resistance, inductive or capacitive reactance) or $2\pi f\ (10^{-7})$ microhms (conductance, inductive or capacitive admittance). For any given measurement, the expression among the foregoing which is largest will automatically apply.



The Ratio Box has two 1000-ohm ratio resistors, which are adjusted to within 0.01 percent (d.c.) of each other and are balanced for capacitance to better than 0.5 micro-microfarad. At a frequency of



50,000 cycles per second, their resistance is within 0.04% of their d.c. resistance, and their phase angle is not more than 1.5 degree. This unusually close approach to d.c. characteristics is due to the fact that the resistors are woven to a new and patented pattern, originated for use at audio, carrier and radio frequencies.

The box contains auxiliary resistance and capacitance for use in securing the initial balance after grounding. There is a 1-ohm slidewire, by which a balance to 0.01 ohm may be secured in inductance measurements even when using a resistance standard adjustable in minimum steps of 1 ohm.

The Ratio Box has an aluminum case and top plate, and shielded terminals. It measures 10½x6x8 in. and weighs 15 lbs.

[1] See *Bell System Technical Journal*, Vol. 8, 1929, pages 560-575.

New Vacuum Tube

General Electric Co.

THIS new "low noise" vacuum tube, designated as the type PJ-11 Pliotron, differs particularly from the usual tube in the degree of vacuum that has been attained. In the ordinary tube the gas pressure within the tube is of the order of a millionth of an atmosphere; the new tube has been exhausted to a billionth of atmospheric pressure.

The "low noise" tube makes it possible to detect voltages of the order of

1/10,000,000 volt. It has been possible to do this at radio frequencies for some years, but when attempts were made to amplify voltages whose frequencies were less than 1000 cycles per second it was found that voltages of less than 1/10,000 volt were masked by large random disturbances. When these disturbances are made audible by a loudspeaker they appear as a loud crackling and hissing noise.

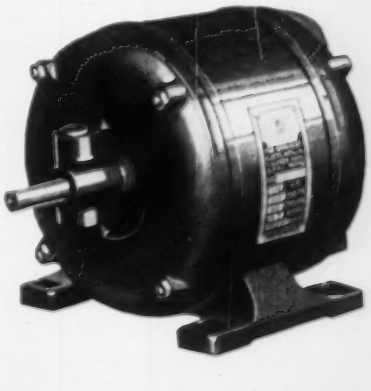
The new tube, reducing this noise between 100 and 1000-fold, makes it possible to measure accurately voltages as small as one millionth of a volt, and to detect voltages ten times smaller, at any frequency from zero (direct current) to a million or more cycles per second.

◆ ◆ ◆

Fractional H. P. Motor

Sunlight Electrical Mfg. Co.

FOR motor driven control appliances this new line of fractional h. p., split-phase motors afford a power unit claimed to run much cooler than the usual small motor. This is due to the large fan embodied within the motor, which keeps cool air constantly circulating through it.

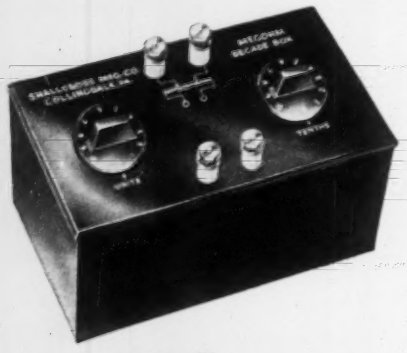


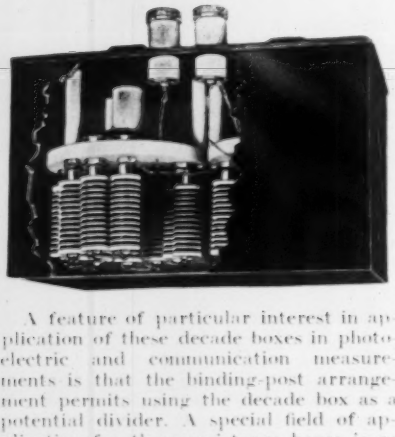
Megohm Decade Resistance Box

Shallcross Mfg. Company

A DECADE resistance box in the very unusual resistance range of megohms is afforded by this new variable resistance standard.

Each decade of resistance contains ten resistor coils wound to reduce capacity and inductive reactance to a minimum. Coils are each impregnated so calibration will not be affected by humidity. Isolantite is used as insulation for all leads and as separator for mountings, thereby keeping over-all leakage resistance, it is claimed, above 1,000,000 megohms.





A feature of particular interest in application of these decade boxes in photoelectric and communication measurements is that the binding-post arrangement permits using the decade box as a potential divider. A special field of application for these resistance boxes is as voltmeter multipliers in conjunction with milli-and microammeters.

Maximum resistances per box of 1.1, 11, and 60 megohms are available in steps of 0.01, 0.1, and 1.0 megohms. Ordinarily the resistors can dissipate one watt per step, but the box, being of cast-aluminum, can be filled with oil to the top of the switches so that the heat of greater loads can be taken care of.

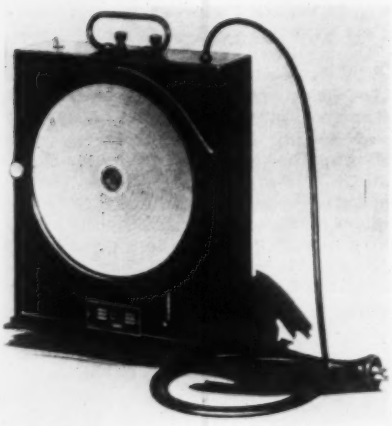
Maximum voltage, 5000 volts; calibrated to 0.1% accuracy; dimensions 5½" × 7" × 9".

◆ ◆ ◆

Portable Recording Pyrometer

Hoskins Mfg. Co.

PRIMARILY intended for portable use, this recording pyrometer uses a self-starting synchronous motor for driving the chart with the desired timing. The motor operates directly off the line, so one need only plug the recorder into any 110 volt socket to put it into operation. The record is formed by a series of dots on the translucent chart, the dots being recorded every 30 seconds by the impress of a stylus against carbon paper laid under the chart. Automatic cold-end compensation is provided, and calibration is for Chromel-Alumel couples. Several ranges are provided in both the Centigrade and Fahrenheit scale, up to 2500° F. and 1400° C.



◆ ◆ ◆

New Automatic Combustion Indicator

C. J. Tagliabue Mfg. Co.

THIS NEW automatic combustion indicator is in every respect a mechanical Orsat, automatically taking samples of the flue gas, analyzing them for CO_2 and unburned gases, and indicating and recording the results.

The apparatus consists of two main parts, the instrument itself and the motor-driven caustic pump. The pump supplies the instrument with caustic potash solution at a constant pressure of 15 lbs. This solution operates the mercury pump 1 and also supplies a fresh quantity of solution for the absorption chamber 38 after each analysis.

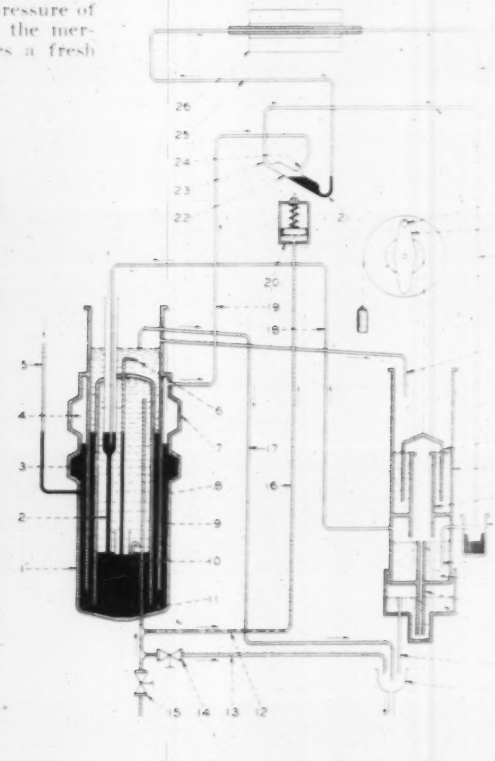
The principal parts of the instrument are as follows:

Mercury pump 1, into which is placed 380 cc. of clean mercury. This pump draws in a sample of gas during the suction stroke and forces the gas through the instrument for analysis during the pressure stroke. Volumeter 3-4 measures a 150 cc. sample of gas; 50 cc. of this amount is used to clean out the gas lines and 100 cc. is used for the analysis.

Orifice valve 15 governs the flow of the caustic potash solution from the caustic pump into the compression tank 8. The orifice is not adjustable. Its size is such as to cause a complete stroke every 90 to 105 seconds.

Suction seal 36 allows the gas sample to pass to the absorption chamber 38 during the pressure stroke but seals against any return of the gas sample during the suction stroke. Absorption chamber 38 contains caustic potash solution which absorbs the CO_2 as the gas sample bubbles through it. Measuring bell 33 receives the gas sample after the CO_2 has been removed and rises in proportion to the volume of gas which enters it, causing bell crank 30 to move and actuate the indicating and recording mechanism.

Directing valve 22 determines the course of the gas sample after leaving the volumeter. In the position shown the gas would pass directly to the absorption chamber as the lower end is sealed with mercury. If it is tilted in the opposite direction, the gas sample would first pass through electrical furnace 26 before entering the absorption chamber. The electrical furnace 26, which contains a copper oxide cartridge under a temperature of 700° C., burns any CO present into CO_2 and any CH_4 and H_2 present into CO_2 and H_2O. The cartridge is kept in the oxide state by the O_2, which is always present in the flue gases.



INSTRUMENTS ABSTRACTS

Abstracts on instruments and devices for measurement, inspection and control.

INSTRUMENTS ABSTRACTS, incorporated in INSTRUMENTS, is the most complete review on the subjects of measurement and control.

Abstractors cover over 500 domestic and foreign publications.

Upon receipt of the abstracts they are checked against permanent files to avoid duplication and after being rewritten to conform to our style they are classified.

Oftentimes an abstract can fit under two or even more sections. In that case we decide who will be most interested in the article, and include it under that field of reader interest. It is our aim to so arrange the abstracts that a person interested, for example, in viscosity, will keep in touch with all the important articles in his field if he reads only section 2.10. For instance, an article on "Vacuum Tube Means of Measuring Viscosity" appears under 2.10—under "Measurement and Control of Physical Properties—viscosity," although it would also fit under section (5.4)—"Electronic Devices and their Applications."

An improvement we hope to make in the Abstracts Section in the near future is the cross-indexing of articles which fit under several sections. We suggest glancing through the whole Abstract Section. This takes but a short time, and the time so taken will be found very profitably spent.

The classification number at the end of each abstract will be of assistance in mounting them on file cards.

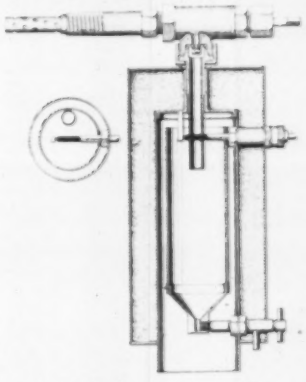
Negative print photostats of the original articles abstracted can be obtained at 35 cents per page plus 10 cents for mailing. The remittance should accompany the order.

CLASSIFICATIONS
(By Fields of Reader Interest)

MEASUREMENT TECHNOLOGY (1)
This section includes all matters concerning the art and science of measurement as follows:
Measurement Theory (1.1)
Under this heading will be included: definitions, precision of measurements, systems of units, and dimensional analysis.
Measurement Practice (1.2)
Covers Calibration and Standardization.
Calculation (1.3)
This does not include computation for instrument design, but covers calculations as a mode of measurement.
MEASUREMENT and CONTROL (2)
This section is devoted to those general measurement practices and control applications that are not confined to any one industry or branch of engineering. Thus temperature measurement and control, being of as much importance in chemical as in metallurgical processes, is a general field of interest to all industries and all branches of engineering.
Length, Angle, and Area, Including Surveying (2.01)
Time, Speed, and Acceleration (2.02)
Weight, Density, and Specific Gravity (2.03)
Pressure and Vacuum (2.04)
Flow and Volume (2.05)
Temperature (2.06)
Heat and Combustion (2.07)
Humidity and Moisture (2.08)
Power, Work, and Output (2.09)
Physical Properties, (Viscosity, hardness, elasticity, plasticity, surface tension, etc.) **(2.10)**
TESTING and INSPECTION (3)
Physical Testing and Inspection (including strength tests, bending, magnetic analysis, X-ray inspection, and other engineering test or inspection methods.) **(3.1)**
Production Testing and Inspection (This includes methods of testing and inspection for setting up production standards, grading, gaging, maintaining quality, etc.) **(3.2)**
Maintenance Testing and Inspection (Included here will be matters concerning standards and methods for controlling performance or service of equipment. Example—The problem of controlling long phone lines to give quality sound transmission would be included here.) **(3.3)**
ELECTRICITY and MAGNETISM (4)
Electrical Properties, Tests, Measurements, and Measuring Instruments (4.1)
Electrical Measuring Devices and Applications (4.2)
Magnetic Measurements (4.3)
Magnetic Properties, Materials, and their Applications (4.4)
ELECTRONICS and RADIO (5)
Radio Measurements (5.1)
Applications of Radio to Measurement and Control (5.2)
Photo-electric Measurements, Devices and Applications (including television) **(5.3)**
Electronic Measurements, Tubes, Devices, and their Applications (Under this heading would be included thermionic tubes, grid-glow tubes, thyratrons, neon discharge tubes, cathode-ray tubes, etc.) **(5.4)**
ACOUSTICS and VIBRATIONS (6)
Sound, Vibration, Phenomena and Measurements (6.1)
Sound and Vibration Devices or Applications (6.2)
LIGHT, OPTICS, and RAYS (7)
Light—General Measurements and Optical Applications (7.1)
Color Analysis, Color Matching (7.2)
Photometry (7.3)
Polarimetry (7.4)

(Continued on page A16)

WHEN YOU BUY
Steam Calorimeters



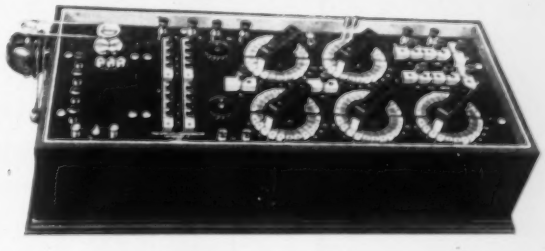
SEE

1 That the calorimeter has a U path steam flow, entering and leaving at the top.
2 That the steam throttles, separates and reevaporates in a single chamber.
3 That the steam chamber is surrounded with steam of the same temperature.
4 That the adiabatic construction is within 2° F. of the theoretical temperature.

Bulletin Eight describes this remarkably accurate instrument—ELLISON U Path Steam Calorimeter

ELLISON DRAFT GAGE CO.
214 W. KINZIE STREET CHICAGO

Electrical Measuring Instruments
for Precise Determinations

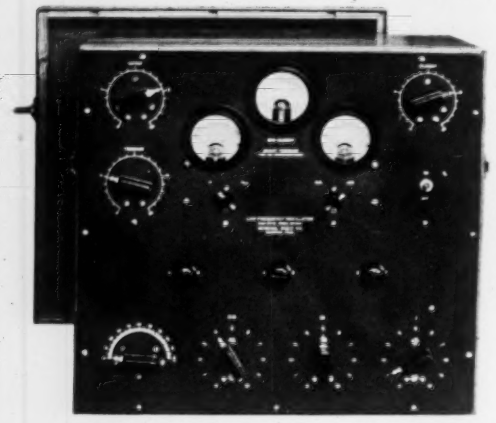


Improved Feussner Potentiometer
Multiplier
Standard Cell Comparing Potentiometer
Modified Mueller Temperature Bridge
Thermometer Commutator
Platinum Resistance Thermometers
Kelvin Double Bridge (illustrated)
Per Cent Bridge

Standard Cells

EPPLEY
THE EPPLEY LABORATORY, INC.
SCIENTIFIC INSTRUMENTS
NEWPORT, R. I.

AUDIO OSCILLATOR



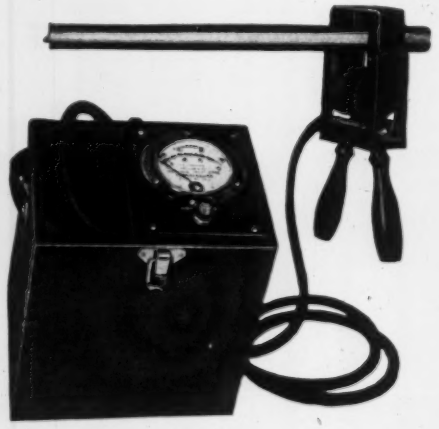
THE General Radio TYPE 377-B Low Frequency Oscillator shown in the above photograph is a vacuum-tube oscillator covering the audio-frequency range between 25 and 70,000 cycles per second. It is distinguished by its high order of frequency stability and its excellent waveform.

For general purpose experimental work requiring the finest type of oscillator, we can recommend this instrument without hesitation.

Its price is $350.00. Write for literature.

GENERAL RADIO COMPANY
CAMBRIDGE A, MASSACHUSETTS

RUBICON CURRENT TEST SET



A highly convenient instrument for measuring alternating currents without interrupting service. Described in Bulletin No. 180. Write for your copy.

RUBICON COMPANY
Electrical Instrument Makers
29 N. 6TH STREET PHILADELPHIA, PA.

ELECTRICITY AND MAGNETISM (4)

Electrical Properties, Tests, Measurements and Measuring Instruments (4.1)

A Directly Indicating Instrument for Measuring Higher Harmonics. (Ein unmittelbar anzeigendes Oberwellenmessgerät.) E. HUETER. *Electrotechnische Zeitschrift*, Vol. 52, [illegible] 1931, pages 471-474.

The instrument consists of a condenser and a reactance coil with iron core and variable airgap, a frequency changer for changing the windings of the coil to resonance with 150, 250, 350 and 450 cycles, i.e. to the third, fifth, seventh and ninth harmonics. For these frequencies the respective connections give, together with the properly adjusted airgap, a resonance circuit and the instrument shows greatest deflections. The error for the resonance reading due to the other harmonics is determined; the instrument is calibrated for reading of the voltage of the harmonic and of the actual voltage so that the percentage of the former can be calculated. The instrument is built by the A.E.G.-Berlin. Ha (4.1)

A New Megohm Meter. (Ein neues Megohmmeter.) W. JAEKEL. *Zeitschrift Verein deutscher Ingenieure*, Vol. 75, March 14, 1931, page 316.

Brief description of a double-coil instrument with magneto, by Siemens & Halske. (4.1)

The New V D E—Rules for Measuring-Transformers. (Die neuen V D E—Regeln für Wandler.) GEO. KEINATH. *Elektrotechnische Zeitschrift*, Vol. 52, May 21, 1931, pages 657-659.

The revised rules for instrument transformers of the Verband Deutscher Elektrotechniker are reprinted in full; they refer to rating, overload capacity, thermal limit current, dynamic limit curent, magnitude of errors, standard currents and voltages, terminal designations and markings, heating for normal operation, grounding, insulation and name plates. Definitions of the quantities are given for each paragraph. Ha (4.1)

Calibration of the Thermo-Wattmeter. (Eichung des Thermowattmeter.) *Elektrotechnische Zeitschrift*, Vol. 52, May 14, 1931, page 637.

The theory of the instrument shows that the deflection of the instrument indicating the output must be reduced by the product of the square of the current flowing through the instrument with a constant, in order to obtain the true output. (4.1)

Alternating Current Null-Galvanometer. (Wechselstrom Nullgalvanometer.) *Elektrotechnische Zeitschrift*, Vol. 52, June 1931, p. 845.

Moving coil instrument to be used in connection with measurements in the Wheatstone bridge, has a sensitivity of 10^{-7} amp. The diagram of connections is explained. Ha (4.1)

Transformation Errors and Measuring Errors in Measurements with Instrument Transformers. (Uebersetzungsfehler und Messfehler bei Messungen mit Wandlern.) G. HAUFFE. *Elektrotechnische Zeitschrift*, Vol. 52, July 9, 1931, pages 900-901.

The author points to the not distinct definition of transformation error and measuring error of instrument transformers which he explains theoretically. He advocates the adoption of a uniform definition for which he develops mathematical expressions clearly distinguishing between the two conceptions. Ha (4.1)

Determination of Amplitudes of Voltages Varying With Time by Means of Glow-Tubes. (Bestimmung der Amplituden von zeitlich veränderlichen Spannungen mittels Glimmlampen.) SIEGFRIED FRANCK. *Elektrotechnische Zeitschrift*, Vol. 52, July 9, 1931, pages 901-902.

A method is described and diagrams of connections are given to determine the maximum voltage by connecting a glow tube to a part of the resistance across the voltage to be measured. If the voltage at which the tube begins to glow is known, the maximum voltage is calculated from the ratio of the part to the total resistance. Ha (4.1)

An Improved Feussner Type Potentiometer. MARION EFFLEY & WILLIAM R. GRAY. *The Review of Scientific Instruments*, Vol. 2, No. 4, April 1931, pages 242-249.

Two improvements in design can be made, one to both the earlier and the later forms of Feussner type potentiometers as currently imported into this country; the other to the self-checking type only. These improvements are the elimination of six contact resistances affecting the measuring circuit, and the addition of another standard cell dial, making it possible to adjust the standard cell circuit to five places instead of to only four. In addition, a battery rheostat can be built into either instrument. The diagram of Rayleigh's arrangement of the Feussner circuit is illustrated and explained. Another diagram shows the Feussner network with the Brooks standard cell coil added. A double contact switch is described and illustrated which has eliminated the six unnecessary contact-resistances of the switch currently used in the best known imported models. Photographs are shown of the potentiometer as finally developed. Results have borne out expectations. MFB (4.1)

A Dynatron Vacuum Tube Voltmeter. R. DE COLA. *Electronics*, May 1931, pages 623-624.

The tube used is a pliodynatron, a tetrode arrangement with two grids, one control grid and one high potential grid. The E — I curve of this tube shows negative resistance over a part of the characteristic where an increase in plate voltage gives a decrease in plate current. The sensitivity of this tube voltmeter is as high as 0.05 milliampere for 0.02 volts. Ha (4.1)

A Method for Measuring High Voltages or Low Capacitances. J. A. VAN DEN AKKER. *Review Scientific Instruments*, Vol. 2, May 1931, pages 290-292.

An arrangement is described which connects by means of movable contacts two condensers in different connections so that the high voltage is balanced against that across a potentiometer which can easily be measured. Ha (4.1)

Measurements of Lightning in High-Tension Systems. (Blitzmessungen in Hochspaunungs-Anlagen.) GEO. KEINATH. *Archiv für Technisches Messen*, 1931, section V3362-2, page T18.

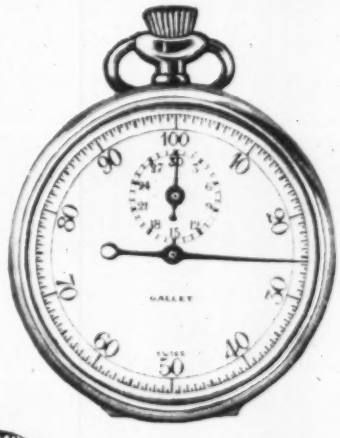
The klydonograph with stationary and moving film, cathode-ray oscillograph, for the recording of lightning as to voltage and current intensity is described. Ha (4.1)

For Accuracy in Work

INSIST ON

Accuracy in Your Timers!

The exact gauging of Time makes for progress, and for sound economics . . . Thus, the importance of accurate, reliable Timers cannot be over-stressed . . . Guinand and Gallet Timers have established the standard of Timer dependability for more than fifty years . . . These splendid instruments constitute the largest lines of Timers available for industrial and laboratory use, and comprise a vast range of "special" Timers for specific purposes . . .



No. 309 Gallet

100 second Timer for viscosity Tests and other Technical uses. Registers up to 3000 Seconds. Start, stop and Fly back from crown. 7 Jewel Lever movement, non-magnetic; shockproof. Chrome Finish Nickel Case $24.50

Other Gallet Timers from **$16.80 upward.**

No. 703
C. L. Guinand

Time Study Production Timer. 30 Minute Register. Start, stop and fly back from crown. Side-push for time out; fine 7 jewel lever movement, non-magnetic. Chrome Finish Nickel Case—**$43.40.**

Other Guinand Timers from **$42.00 upward.**

Guinand and Gallet Timers for standard usage are available immediately at leading instrument dealers. If unobtainable locally, write us and we will see that you are promptly supplied.

A detailed catalog of Guinand and Gallet Timers—of special interest to industrial plants and laboratories—will be sent on request.

JULES RACINE & CO.

20 W. 47th ST. NEW YORK

GUINAND and GALLET TIMERS

Energy Measurement of High-Capacity Circuit Breakers. (Leistungs-Messung an Hochleistungs-Schaltern.) W. KAUFMANN. *Archiv fur Technisches Messen*, 1931, section V3417-1, pages T41-43.

The definitions for the breaking capacity in different countries are explained and illustrated by oscillograms. The measuring method is described and it is shown how the oscillograms are evaluated. Ha (4.1)

Measurement of Maximum Amplitude of Voltage with Neon-Tubes. (Scheitelspannungsmessung mit Neon-Glimmröhre.) GEO. KEINATH. *Archiv fur Technisches Messen*, 1931, section V3382-1, page T38.

One fixed and one variable condenser are connected in series to the voltage to be measured. A neon tube is connected across the variable condenser whose capacity is gradually diminished until the neon lamp flashes. Then U maximum is equal to $U_3 (1 + C_3/C_2)$ where U_3 is the flash voltage of the neon lamp and C_3 the variable capacity. 6 references. Ha (4.1)

Temperature Measurements in Transformers. (Temperatur-Messung an Transformatoren.) GEO. KEINATH. *Archiv fur Technisches Messen*, 1931, section V2177-1, page T36-37.

The characteristic temperatures of a transformer are: (1) entering temperature of the cooling agent (air or water); (2) temperature of the outgoing cooling agent; (3) temperature of surrounding air; (4) temperature of the top of the oil; (5) average winding temperature calculated from the increase of the resistance; (6) the temperature of the hottest spot of the winding. The methods applied for these purposes are described. Ha (4.1)

Measurement of Peak Voltage by the Sphere Gap. (Scheitelspannungs-Messung mit der Kugel-Funckenstrecke.) GEO. KEINATH. *Archiv fur Technisches Messen*, 1931, section V3381-1, pages T19-20.

The breakdown voltages for a sphere gap can be calculated from the formula of Peek; precautions to take and corrections for barometric pressure and temperature are given. Tables for voltages with different sphere diameters and distances are given. 8 references. (4.1)

Theory of the Current Transformer. (Theorie des Stromwandlers.) GEO. KEINATH. *Archiv fur Technisches Messen*, 1931, section Z21-1, page T48.

The performance diagram of Moellinger-Geweeke is derived and the method of measuring the characteristic quantities for laying out the diagram is described. Ha (4.1)

Electro-Photography of Insulation Material. (Elektrophotographie an Isolierstoffen.) A. GEMANT. *Zeitschrift fur technische Physik*, Vol. 12, April 1931, pages 250-256.

Reports on a method of determining the density and the distribution of finest pores in insulating material. Experiments were performed in the Research Laboratory of the Siemens Schuckert Kabelwerke. EF (4.1)

Frequency Measurement. (Frequenz-Messung.) GEO. KEINATH. *Archiv fur Technisches Messen*, 1931, section V3612-1, page T12.

Technical low frequencies from 5 to 1000 Hertz are measured directly by vibrating lamellae, or indicating instruments which are mostly based on the disturbance of the balance in an electric circuit by the change of frequency. For very exact purposes, comparison with a clock or seconds pendulum is employed. Ha (4.1)

New One-Ohm Standard Resistances of the Bureau of Standards. (Neue 1-Ohm Normalwiderstände des Bureau of Standards.) GEO. KEINATH. *Archiv fur Technisches Messen*, 1931, section Z111-3, page T47.

Complete description of construction and treatment of materials. Ha (4.1)

The Capillary-Electrometer and the Electro-Capillary Curve III. (Zur Kenntnis des Kapillar-elektrometers und der Elektrokapillarkurve III.) F. O. KOENIG. *Zeitschrift fur physikalische Chemie, Section A*, Vol. 157, Nov. 1931, pages 96-112.

The third paper out of a set of publications refers to the temperature irregularities of the electro-capillary curve. EF (4.1)

The Capillary Electrometer and the Electro-Capillary Curve II. Experimental Study of Some Methodic Principles Included in the Theory. (Zur Kenntnis des Kapillarelektrometers und der Elektrokapillar Kurve II. Experimentelle Prüfung einiger mit der Theorie zusammenhaengender methodischer Fragen.) F. O. KOENIG. *Zeitschrift fur physikalische Chemie, Section A*, Vol. 154, May 1931, pages 454-477.

Experiments with an improved capillary electrometer. EF (4.1)

The Capillary Electrometer and the Electro-Capillary Curve I. The Two Thermo-Dynamic Assumptions and Conclusions Therefrom. (Zur Kenntnis des Kapillarelektrometers und der Elektrokapillar Kurve I. Ueber die Annahme und einige Folgerungen der beiden thermo-dynamischen Ansaetze.) F. O. KOENIG. *Zeitschrift fur physikalische Chemie, Section A*, Vol. 154, May 1931, pages 421-453.

Fundamental principles involved in the capillary electrometer and the electro-capillary curve. Application of Gibb's Absorption Law. EF (4.1)

A Method for Measuring Very High Values of Resistance. G. M. ROSE JR. *Review of Scientific Instruments*, Vol. 2, Dec. 1931, pages 810-813.

A simple, low-voltage method of measuring resistances above 10^9 ohms is described. A special vacuum tube, having almost infinite input leakage resistance, is used. The unknown resistance and a standard resistance of nearly equal value are in series across a battery, and the standard resistor across the input (grid). The current through the standard resistor produces a biasing voltage across the grid, which increases the plate current of the tube. This current increase is bucked out by adjusting battery voltage on the grid equal and opposite to the voltage across the standard resistor. This bucking voltage is measured by a voltmeter, and the unknown resistance is found by a simple relation between the known standard resistance, the balancing voltage, and the voltage across standard and unknown resistance in series. HO (4.1)

THE REVIEW OF SCIENTIFIC INSTRUMENTS

CONTENTS FOR APRIL, 1932, ISSUE

VOL. 3, NO. 4

A Periodic Radiometer for Eliminating Drifts.

Construction of Thermo-Elements by Electro-deposition.

An Infrared Spectrometer of Large Aperture.

A Large Grating Spectrograph.

An Airplane Experiment for the General Physics Laboratory.

Send Subscriptions to

F. K. RICHTMYER, *Managing Editor*
Cornell University, Ithaca, N. Y.

Annual subscription Four Dollars per year, post paid; combined Subscription with the Journal of the Optical Society of America, Five Dollars per year.

Electrical Measuring Devices and Control Equipment or Applications (4.2)

Supervision of the State of Insulation of Non-Grounded Direct Current Systems with a Watt-Meter Instrument. (Die Ueberwachung nicht geerdeter gleichstromnetze mit einem wattmetrischen Instrument.) W. BUETOW. *Elektrotechnische Zeitschrift*, Vol. 52, April 16, 1931, pages 502-504.

Isolated d. c. systems, especially such serving as auxiliary systems for the supervisory-control of AI systems, must be particularly guarded against failures due to breakdown of the insulation. The described arrangement uses a [illegible] transformer, sending an alternating current into the system in case of failure. The ground current goes through one coil of a wattmetric instrument while the other is connected directly to the ends of the little transformer. The proper phase relation between the two currents is adjusted by a condenser with an ohmic resistance in parallel in series with the stationary coil of the instrument. Very small currents are indicated either audibly or visually; for permanent supervision a recording instrument can be used. Ha (4.2)

A Rapid-recording Oscillograph. A. M. CURTIS AND I. E. [illegible]. *Electronics*, Vol. 3, Aug. 1931, pages 70-71.

The new instrument can record phenomena of vibrations up to 6000 cycles per second, and combines a string galvanometer, photographic mechanism, and a time measuring device. The sensitivity at 6000 cycles is 9 milli-amperes per millimeter. The construction is described in detail. Ha (4.2)

A New Transformer for Highest Voltages. (Ein neuer Spannungswandler für Hochstaspannungen.) J. [illegible]. *Elektrotechnische Zeitschrift*, Vol. 52, March 19, 1931, pages 378-379.

See *Instruments* abstract; *Forschung & Technik*, 1930, pages 313-318. (4.2)

The Complete Relay Tester. ORLEN A. PENDLETON. *Electrical World*, Vol. 97, May 16, 1931, pages 904-905.

The Empire District Electric Co. has assembled, into two carrying cases, a set for the routine and special testing of relays. One case contains a special tapped transformer and its related devices for furnishing various current quantities and the other case contains the testing instruments. The wiring layouts are shown in diagram. Features of the testing assembly are: (1) accurate current quantities can be obtained from ¾ to 200 amperes on either 25- or 60-cycle, 110 to 220 volt circuits; (2) secondary voltages can be obtained in 5-volt steps from zero to 40; (3) phase rotation can be checked instantly; (4) timing of oil circuit breakers can be obtained with no additional equipment; and (5) operation of auxiliary contactor switch and operation indicator can be tested by pushing a button. WHB (4.2)

An Improved Model of the Neon-Tube Contactor. HUGO J. REICH. *The Review of Scientific Instruments*, Vol. 2, No. 4, April 1931, pages 234-236.

Description of a much simpler and more reliable model of a periodic contactor operated by a neon-tube oscillator. The new device will operate satisfactorily on any source of [illegible] capable of supplying 30 milliamps at from 350 to 500 volts. Wiring diagram and complete list of apparatus (giving manufacturers' names) are given. MFB (4.2)

Theory of a Combined Series and Potentiometer Rheostat. J. RUD. NIELSEN. *Review Scientific Instruments*, Vol. 2, March 1931, pages 184-186.

Derivation of a formula for a rheostat permitting a rapid change from series to potentiometer connection; a diagram shows the change of current with resistance. Ha (4.2)

Design and Construction of the Telomat. WARREN H. [illegible]. *Michigan Engineering Experiment Station Bulletin No. 38*, June 1931, 13 pages.

The Telomat is a device for the supervision of remote control systems which can be operated over any telephone line in service; it has provisions for controlling five circuits. The apparatus is operated by two tones or notes and by using these notes at the proper instant as determined by the buzzer signals sent back by the device, any of the five circuits may be opened or closed. The receiver hook is automatically lifted when a call is made and lowered when the call, that is the required operation, is completed. The apparatus is described in detail and diagrams of connections for three different purposes show the control of an electrical substation, a pumping station, and a lighting system. Ha (4.2)

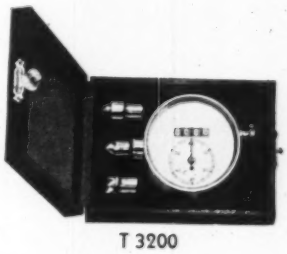
A Micro-Time Switch. (Ein Mikro-Zeitschalter.) L. [illegible]. *Elektrotechnische Zeitschrift*, Vol. 52, July 9, 1931, page 899.

An arrangement consisting of spark gaps, resistances, and condensers, is described with which testing voltages of any desired duration can be produced. This arrangement can also be used for releasing a secondary occurrence during a predetermined time after a spark. For times of one millionth of a second a conductor of 300 m is required. The diagram of connection is given. Ha (4.2)

New Power Oscillograph is Automatic and Quick-Acting. C. ANDERSÓN & S. C. LEYLAND. *Electrical Journal*, Vol. 28, May 1931, pages 281-284.

The new four-element power oscillograph is designed primarily for recording transient disturbances. It incorporates a more efficient optical system, magnetic clutch and shutter, an integrally-mounted film holder motor which runs continuously, and self-contained control and automatic operation panels. The complete instrument is illustrated. It operates automatically after the appearance of a fault on the circuit and gives a record of instantaneous values during and following the disturbance. The initial time, from the appearance of the fault to the first visible record on the photographic film, is from 1/120 to 1/60 second, the time varying with the % overload in the initiating-relay coil. Simplified operation without the magnetic shutter and clutch has an overall initiating time from 1/30 to 1/20 second. Operating economies and conveniences are claimed for the apparatus, as well as great flexibility and initiating-speed with dependability. WHB (4.2)

SPEED INDICATOR



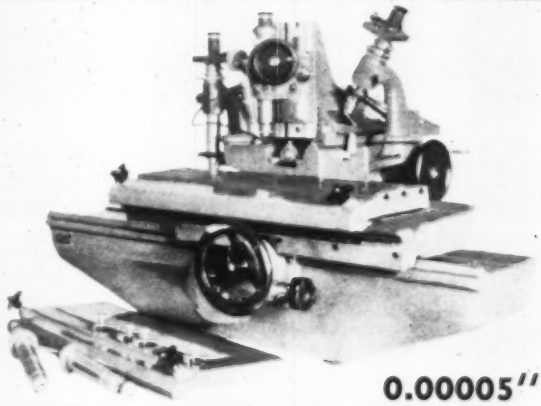
T 3200

An accurate, sturdy speed indicator with an anti-magnetic stop-watch. Complete with two extra rubber contact tips, in plush lined leatherette case $15.00

Write for bulletin No. 128 describing this and other useful instruments.

★

The GAERTNER SCIENTIFIC CORP.
1201 WRIGHTWOOD AVENUE CHICAGO, U.S.A.



0.00005"

ONE STANDARD OF ACCURACY

Every measurement is made to the same high precision with this machine. It will check any dimension up to 16" on solid or transparent objects. With it you can make regular tests of all your inspection instruments, from plug gauges to dial indicators. It is a product of the

Société Genevoise d'Instruments de Physique
"Masters of the art of measurement"

Ask for Your Copy of Pamphlet No. 548

THE R. Y. FERNER COMPANY
1131 Investment Bldg. Washington, D. C.

Magnetic Measurements (4.3)

Ballistic Measurements of Highly Permeable Materials. (Ueber ballistische Messungen an hochpermeablen Materialien.) HANS NEUMANN. *Wissenschaftliche Veröffentlichungen aus dem Siemens-Konzern*, Vol. 10, March 1931, pages 55-71.

Two ballistic methods, the wire method and the ring method, are described for measuring materials of very high permeability; the errors are determined. The magnetic properties of Fe-Ni-alloys with small additions of Co are given which show that, for certain amounts of Co, an increase in the original and maximum permeability takes place and the coercive force is decreased. Numerous curves and 18 references are given. Ha (4.3)

A Practical Magnetometer for Iron Investigations. (Ein praktisches Magnetometer für Eisenuntersuchungen.) K. KUHLMANN. *Archiv Elektrotechnik*, Vol. 49, Nov. 12, 1931, pages 776-780.

The usual magnetometer method measuring the deflection of the needle in the earth field has been modified to a zero-method which eliminates the errors due to the movements of the needle and makes possible the use of this method for practical purposes also. The theory is developed and the method illustrated. Ha (4.3)

Magnetic Properties, Materials, and Their Applications (4.4)

Measurement of Magnetic Losses of Iron Strips at Homogeneous Saturation. (Messung der magnetischen Verluste an Eisenblechstreifen bei homogener Sättigung.) J. SCHNEIDER. *Elektrotechnische Zeitschrift*, Vol. 52, July 9, 1931, page 910. *Archiv Elektrotechnische*, Vol. 24, 1931, page 651.

The requirements for a correct measurement of magnetic losses, especially in the Epstein-apparatus are discussed and a form of yoke is developed according to theoretical considerations which results in a homogeneous saturation in the iron sample. The losses are measured in a part of the magnetic circuit of homogeneous saturation, which show for hypersaturation differences with the Epstein-apparatus due to additional eddy losses in the latter. The errors in the new method are discussed in detail. Ha (4.4)

Permanent Magnets for Electronic Instruments. W. H. HOOPER. *Electronics*, May 1931, pages 636-638.

The material for permanent magnets should be machinable, easily hardened, and have high magnetic retentivity. Some magnetic characteristics of magnetic steels are briefly described and formulas for calculating magnet dimensions and leakage explained. An example is given. Four references are cited. Ha (4.4)

New Permalloys. G. W. ELMEN. *Bell Laboratories Record*, Vol. 10, Sept. 1931, pages 2-5.

Permalloy containing 78.5% Ni and 21.5% Fe was tested to increase its usefulness in alternating current circuits by giving it a higher resistivity and also to simplify its heat treatment. The addition of either Cr or Mo accomplished the first purpose and also tends to increase the initial permeability. The addition of 3-5% caused an appreciable effect in this direction. Characteristic curves and data on heat treatment and Curie point (at which the material becomes unmagnetic) are given. Permalloy is particularly useful in telephone circuits and instruments. Ha (4.4)

The Position of the So-Called "Knee" of Magnetizing Curves. (Über die Lage des sogenannten "Knie" bei der Magnetisierungskurve.) K. M. KOHLER. *Elektrotechnische Zeitschrift*, Vol. 52, April 2, 1931, page 456. *Elektrotechnik & Maschinenbau*, Vol. 47, page 1141.

The "knee" means that bending in the magnetization curve which leads over to the saturated part. Kohler defines this point by the expression $\delta = \frac{t}{y}$, where y is the ordinate of a point of the curve and t the length of that section which is cut off on the ordinate axis by the tangent at the respective point. This expression becomes zero for magnetization becoming zero, and is unity for strong magnetization. Ha (4.4)

Design and Construction of an Electromagnet for Investigation of the Magnetic Properties of Atoms and Molecules. E. J. SHAW. *Review Scientific Instruments*, Vol. 2, Oct. 1931, pages 611-617.

Detailed description of an electromagnet which can produce a magnetic field density of 148,000 lines per sq. in. when the two polefaces of 4 in. dia are 10 mm. distant. The temperature rise in the windings even at continuous operation is not more than 50°. A few tests in which the magnet can be used are described. Ha (4.4)

The Magnetic Properties of Perminvars. (Ueber die magnetischen Eigenschaften der Perminvare.) H. KUSSMANN. *Wissenschaftliche Veröffentlichungen aus dem Siemens-Konzern*, Vol. 10, March 1931, pages 72-78.

The property of the perminvar materials—that is the constancy of the original permeability up to comparatively high magnetizing fields—which makes them so valuable in the construction of instruments, is not yet fully explained. As certain the following results can be stated: 1. The different shapes of the hysterese loops of perminvars all form a continuous series; 2. an increase of the perminvar character in the Elmen perminvar range can be obtained either by greater contents of cobalt or by annealing at higher temperature; 3. hysteresis loops of perminvar character can be obtained only if the cooling after annealing goes on very slowly; 4. in the system iron-nickel-cobalt another perminvar range exists besides that of Elmen which lies very close to the iron-nickel series; 5. the more pronounced the perminvar character of an alloy is the more difficult it is to demagnetize it; some kinds can be demagnetized only by annealing. Numerous diagrams illustrate the paper, 7 references. (4.4)

Spectrometry (7.5)
Photography (7.6)
Microscopy (7.7)
Electromagnetic Rays (This heading covers all electromagnetic rays other than visible light: infra-red, heat rays, ultra-violet, X-rays, alpha, beta, gamma, cathode, and cosmic rays.) **(7.8)**

CHEMISTRY (8)
Under this heading will be chemical measurements, analysis, and their control applications.

ASTRONOMY, NAVIGATION, AVIATION (9)
Included in this section will be, besides usual matters concerning astronomy, navigation and aviation, special matter on direction-control such as range finding, direction finding, radio beacons, etc.

GEODESY, GEOLOGY (10)
In this section will be covered seismology, geophysical prospecting methods, etc.

INSTRUMENT DESIGN and CONSTRUCTION (11)
Matters concerning new instruments, their design, operation and manufacture, will be included under this heading.

GENERAL and MISCELLANEOUS (12)
This section will include: First; general items of interest to all in the field of measurement and control. Example—"Possibilities of Vacuum Tubes for Application to Measurement and Control" is an article of universal interest in the fields of measurement and control. Second; miscellaneous items of general interest because not includable under any of the above classifications. Finally, items of general interest to all fields of measurement and control, such as historical material, biographical, etc.

General (of interest to all in measurement or control fields) **(12.1)**
Miscellaneous (12.2)
Historical and Biographical (12.3)
Bibliographical (12.4)
Economic (12.5)

CONTROL FUNCTIONING EQUIPMENT (13)
Literature on the equipment used by operators or automatic controllers to perform their control functions will be covered under this heading. For example, the drum controller and associated switches, rheostats, relays, and motor starters by which an operator controls the motion of a crane are all pieces of "control functioning equipment."

Mechanical Control Functioning Equipment (13.1)
Electrical Control Functioning Equipment (13.2)
Includes drum controllers, relays, solenoids, etc.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912

of INSTRUMENTS published monthly at Pittsburgh, Pa., for April, 1932. State of Pennsylvania, County of Allegheny, ss.

Before me, a Notary Public in and for the State and county aforsesaid, personally appeared Richard Rimbach, who, having been duly sworn according to law, deposes and says that he is the publisher of the INSTRUMENTS and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, Richard Rimbach, Pittsburgh; Editor, Richard Rimbach, Pittsburgh; Managing Editor, Richard Rimbach, Pittsburgh; Business Manager, Joseph J. Vigneau, Pittsburgh.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.) Instruments Publishing Company, 3619 Forbes Street, Pittsburgh; Jos. J. Vigneau, Pres.; Richard Rimbach, V. P., Treas.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.) None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stocks, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is (This information is required from daily publications only.)

RICHARD RIMBACH, Publisher.

Sworn to and subscribed before me this 22d day of March, 1932. [Seal] E. T. CHANCE, Notary Public.

(My commission expires March 7, 1933)

ELECTRONICS AND RADIO (5)

Radio Measurements (5.1)

The Absolute Measurement of Radio-Electric Frequencies. (La mesure absolue des fréquences radioélectriques.) *Revue Générale de L'Electricité*, Vol. 29, May 2, 1931, pages 710-722.

The primary standard is, of course, the pendulum of a frequency of one second. Secondary standards are based on the elastic vibrations of tuning forks held in vibration by electric impulses, or the vibrations of certain crystals under the action of electric forces, or magnetic oscillators. These different types permit covering a range of 50 oscillations to 60,000 oscillations per second. The measuring methods by these standards are described. Ha (5.1)

High-Frequency Measuring Arrangement for the Determination of Dielectric Constants. (Hochfrequenz-Messeinrichtung zur Bestimmung der Dielektrizitätskonstanten.) KURT SCHLESINGER. *Elektrotechnische Zeitschrift*, Vol. 52, April 28, 1931, pages 533-534.

A new bridge arrangement operating with high-frequency is described, which has a condenser with a division reading directly the dielectric constant in micro-farad. This is made possible for any non-calibrated measuring devices by using a special bridge-adjustment at no-load as long as the capacity of this measuring device is large compared with the small capacity of the wires in the arrangement. The use of frequencies between 10^5 and 10^7 Herz and the application of an amplification of 1000 permits a sharp minimum even for conducting liquids. The practical accuracy is about 1 to 2%. Ha (5.1)

Measurement of Temperature Coefficient and Pressure Coefficient of Quartz Crystal Oscillators. S. LEROY BROWN & SIDEN HARRIS. *Review Scientific Instruments*, Vol. 2, March 1931, pages 180-183.

A method of measurement is used whereby variation in frequency of a high frequency oscillator can be measured to a fraction of a part in a million by comparison of the tone of a variable audio frequency to the audible harmonic frequency. Both influences of temperature and pressure are fairly small. Ha (5.1)

Dosimeter for the Determination of Energy in Rapidly Oscillating Circuits. (Dosimeter zum Bestimmen der Leistung in sehr schnell schwingenden Stromkreisen.) K. HUSSRICH. *Elektrotechnik und Maschinenbau*, Vol. 49, Nov. 8, 1931, pages 831-833.

A measuring arrangement is described in which the glowing of an incandescence lamp is used which is connected with one pole to the high-frequency circuit; the photometric determination is made by a photocell. Ha (5.1)

Measuring the Frequencies of Radio-Signals. A. A. ROETKEN. *Bell Laboratories Record*, Vol. 9, Aug. 1931, pages 585-588.

Interference between radio systems due to variations in their carrier frequencies must be avoided; the methods of measuring frequencies used in recent years are based on relating an unknown frequency to an appropriate multiple of a known standard frequency. The fundamental principle is to combine the frequency to be measured with a known frequency of such value as to produce a beat frequency of value one digit less than that of the original frequency. This beat frequency is then beaten with a second known frequency to produce a beat frequency of two digits less than the original, and so on. How this can be done in a practical way is described. The measurements have an accuracy of within 0.00015% + 3 cycles in the range of 5 to 30 million cycles. Ha (5.1)

A Voltage Measurement Method for Frequencies up to 1.5×10^8 Hertz. (Eine Spannungsmessmethode für Frequenzen bis zu 1.5×10^8 Hertz.) L. ROHDE. *Zeitschrift für technische Physik*, Vol. 12, April 1931, pages 263-265.

Anticipating previous methods, the author gives his own method, which employs a double electrode tube. Accuracy about 1%. EF (5.1)

Applications of Radio to Measurement and Control (5.2)

A Piezo-Electric Quartz Frequency Meter with Synchronous Modulation. (Un fréquencemétre a quartz piézoélectrique avec modulation synchrone.) B. DECAUX. *L'Industrie Électrique*, Vol. 40, Oct. 25, 1931, page 476.

Radio stations, especially those sending short waves require a very close regulation, of at least 1/1,000,000. The piezo-electric quartz oscillator has a fundamental frequency of several 100,000 periods per second; by inserting inductances in the electric circuit harmonics are produced the frequency of which is determined by comparison with the pendulum clock of the observatory in Paris. Ha (5.2)

Micro-Ray Wireless. *Electrician*, Vol. 106, Apr. 3, 1931, pages 509-510.

A new short wave system was demonstrated by I. T. & T. Laboratories by a conversation between observers on the cliffs on either side of the straits of Dover (England). The system involves the use of centimeters instead of tens, hundreds and thousands of meters. The short waves possess properties akin to those of light vibrations—in that they can be reflected, directed and diverted by the use of devices of an optical character. The transmitter and the receiver are illustrated. WH (5.2)

Photo-Electric Measurements, Devices, and Applications (Including Television) 5.3

Measurement of Fidelity in Television Systems. A. F. MURRAY, *Electronics*, Vol. 3, Oct. 1931, pages 137-138.

The method used in the television transmitter W3XAD to measure the exactness of a light transmission is described. it is essentially the same as used by oculists, by providing charts with different color shades in which each shade bears a definite relation to adjacent shades. Ha (5.3)

INSTRUMENTS INDEX

Of instruments and devices for measurement, inspection or control

If you are unable to find what you require in this section of INSTRUMENTS—write Information Section, Instruments Publishing Company. Give complete information of requirements.

ABRASION TESTERS
Alfred Suter
Atlas Electric Devices Co.

ACCELERATED TESTING CABINETS
Atlas Electric Devices Co.

ACIDITY RECORDERS

ACOUSTIMETERS
Burgess Laboratories, Inc., C. F.

AIR FLOW INDICATOR
Brown Instrument Co.
Foxboro Co.
Hays Corporation
Morey & Jones, Ltd.
Republic Flow Meter Co.
Tagliabue Mfg. Co., C. J.

AIR METERS
Foxboro Company
Republic Flow Meter Co.
Taylor Instrument Companies

ALIDADES

ALTIMETERS
Tagliabue Mfg. Co., C. J.

ALTITUDE BAROMETERS
Taylor Instrument Companies

AMMETERS—Indicating
General Electric Co.
General Radio Co.
Jewell Electrical Instrument Co.
Rawson Elec. Inst. Co.
Weston Electrical Inst. Corp.

Recording
Bristol Company
General Electric Co.
Tagliabue Mfg. Co., C. J.

ANEMOMETERS
Bristol Company
Taylor Instrument Companies

ARMATURE TESTING EQUIPMENT

ASPHALT TESTING APPARATUS
Tagliabue Mfg. Co., C. J.

ATTENUATION NETWORKS
General Radio Company
Rubicon Company

AUDIO-FREQUENCY OSCILLATORS
General Radio Company

BALANCES
Alfred Suter

BALANCING MACHINE
Alfred Suter
Baldwin-Southwark Corp.

BAROMETERS — Aneroid, Mercurial, Recording
Bristol Company
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

BATTERY CHARGING RHEOSTATS
Ward Leonard Elec. Co.

BATTERY TESTERS
Weston Electrical Inst. Corp.

BEARING TESTERS
Burgess Laboratories, Inc., C. F.

BOARDS: INSTRUMENT
Foxboro Co.
Republic Flow Meter Co.

BRAKE TESTING METER
Rawson Elec. Inst. Co.

BRIDGES, ELECTRICAL
Capacity, Inductance, Kelvin, Resistance, Temperature, Wheatstone, Percent
Eppley Laboratory, Inc.
General Radio Co.
Rubicon Company

CABLE TESTERS
Rawson Elec. Inst. Co.
Rubicon Company

CALORIMETERS
Peroxide, Oxygen Bomb
Burgess-Parr Co.
Gaertner Scientific Co.

Steam
Ellison Draft Gage Co.

CAPACITANCE METERS
General Electric Co.
General Radio Co.
Jewell Elec. Inst. Co.
Rubicon Company
Weston Elec. Inst. Corp.

CARBON DIOXIDE METERS
Brown Instrument Co.
Foxboro Co.
Hays Corporation
Republic Flow Meter Co.
Tagliabue Mfg. Co., C. J.

CARBON MONOXIDE METERS
Tagliabue Mfg. Co., C. J.

CATHETOMETERS
R. Y. Ferner Co.
Gaertner Scientific Corp.

CEMENT TESTING INSTRUMENTS
Alfred Suter

CHRONOGRAPHS
R. Y. Ferner Co.
Gaertner Scientific Corp.

CHRONOMETERS
R. Y. Ferner Co.
Tagliabue Mfg. Co., C. J.

CLINOMETER
Baldwin-Southwark Corp.

CLOCKS—Gage Board
Brown Instrument Co.
Bristol Company
Foxboro Co.

CLOUD & POUR TEST APPARATUS
Tagliabue Mfg. Co., C. J.

COILS
Resistance, Inductance, Special.
General Radio Co.
Rubicon Company

COIL TESTING EQUIPMENTS
Rubicon Company

COLOR TESTER
Atlas Electric Devices Co.

COLORIMETERS
Bausch & Lomb Optical Co.
Tagliabue Mfg. Co., C. J.

COMBUSTION CONTROL EQUIPMENT
Bristol Company
Brown Instrument Co.
Hays Corporation
Illinois Testing Lab., Inc.
Morey & Jones, Ltd.

COMBUSTION SAFETY CONTROL
Minneapolis-Honeywell Co.

COMMUNICATION MEASURING INSTRUMENTS
General Radio Company
Rawson Elec. Inst. Co.

COMPARATORS
B. C. Ames Co.
Bausch & Lomb Optical Co.
Federal Products Corp.
R. Y. Ferner Co.
Gaertner Scientific Corp.
General Electric Co.

COMPASS
Taylor Instrument Companies

CONDENSER LEAKAGE RECORDERS

CONDENSERS—Electrical
General Radio Co.
Rubicon Company

CONDUCTIVITY METERS
Indicating, Recording, Controlling
Rawson Elect. Inst. Co.
Rubicon Company

CONCENTRATION RECORDERS

CONSTANT SPEED & FREQUENCY SETS

CONTOUR MEASURING PROJECTOR
Bausch & Lomb Optical Co.

CONTROLS, AUTOMATIC
Combustion
Morey & Jones, Ltd.

Combustion Safety
Minneapolis-Honeywell Co.

The "Electric Eye" Now Enters Industry. *Electronics*, Vol. 3, Oct. 1931, pages 132-135.

Light-sensitive devices are now applied in counting, recording, controlling, regulating, detecting, safeguarding, grading, inspecting, engraving, color matching, visual reproduction, sound production; home possibilities where the use has hardly been developed so far, are discussed. Ha (5.3)

Technique and Aims of Television. (Technik und Ziele des Fernsehens.) A. Karolus & W. Ilberg. *Feinmechanik u. Prazision*, Vol. 39, Apr. 1, 1931, pages 8-13.

Brief description of apparatus, neon-lamps, photo-cells, and devices for the transmission of pictures. The Nipkowdisc, the Weiller mirror-wheel and the reception apparatus are explained and illustrated. Ha (5.3)

Photoelectric Cell is Design Engineer's Latest Ally. Edgar H. Felix. *Machine Design*, Vol. 3, Feb. 1931, pages 27-30, March 1931, pages 47-49.

The light sensitive devices employing photoelectric cells are divided into four classes: 1. those responding to mere presence or absence of light without regard to its intensity or color; 2. those responding proportionately to the total light intensity impressed on them; 3. those depending on reflection or conduction of light of a particular frequency or color; 4. those responding successively to each color of the spectrum and controlling operations according to variations of any or every color constituent. A few examples of applications in each class are illustrated, and the design of actual units explained. Control of weaving and printing machines, color sorting arrangements, safety devices for punching presses and similar tool machinery, registering and recording devices form a part of the continually widening field of application. Ha (5.3)

The Use of Filters with Photoelectric Tubes. Lewis R. Koller. *Review Scientific Instruments*, Vol. 2, March 1931, pages 195-198.

It is shown that the sensitiveness of the method of measuring the concentration of a solution by light passing through it can be greatly increased by the use of suitable filters. This is due to the fact that the change in transmission with concentration is not the same for all wave lengths. A number of tests are reproduced in curves. Ha (5.3)

Power Control by Means of Phototubes. W. R. G. Baker, A. S. Fitzgerald & C. F. Whitney. *Electronics*, May 1931, pages 632-633.

A few diagrams of connections for photo cells to be used in relay circuits, power control, illumination control, smoke density recorder, are explained. Ha (5

Photoelectric Relays and Monorail System Speed Mail Handling. *Steel*, Vol. 89, No. 5, July 30, 1931, pages 31-33.

An installation is described where sorting and directing of mailbags for the different stations is controlled by photoelectric tubes. Ha (5.3)

Electric Eye Means Accurate Heat Treatment. *Metal Progress*, Vol. 21, Jan. 1932, pages 43-45.

The ends of gasoline-engine tappet valves are hardened to resist wear by photo-electrically controlled heat-treating. Intense local heat is applied to the end of the valve stem by passing a heavy electric current across its end. The color-changes of the radiation from the stem-end change the current of a photo-cell. When the stem-end has reached the desired temperature the color of its radiation has changed the photo-cell current to a value at which it operates a relay, shutting off the heat and dropping the valve stem into a quenching bath. Economies and advantages of this method of control are pointed out. Close-up illustration of apparatus is included, but no circuit diagram. HO (5.3)

Electronic Measurements, Tubes, Devices, and Their Applications (5.4)

Construction, Operation and Characteristics of Photoelectric Tubes. Lewis R. Koller. *Journal of Western Society of Engineers*, Vol. 36, Feb. 1931, pages 15-25.

A discussion of the characteristics of the different types of photo-electric tubes that sets forth types of tubes to be used for different applications, with their operating limits for the different services. Metals of the alkali group are used in the tubes. Compounds of these metals change the sensitivities markedly. One of the most useful characteristics of photoelectric cells is the relation between current and illumination. This is strictly linear over a wide range. The photoelectric tube is sometimes called the "electric eye." Alone it is less sensitive than the human eye but with the aid of an amplifier is twenty times as sensitive. Several types of amplifiers are discussed. Where great constancy of operation is required, vacuum tubes should be used. Outstanding applications of the photoelectric tube are television and talking pictures, smoke detectors, counters, bean sorters, light recorders, color analyzers, physical photometers and innumerable control devices. WHB (5.4)

Thyratron Tubes Maintain Tension in Wire Drawing Equipment. *Steel*, Vol. 89, Nov. 3, July 16, 1931, page 54.

The re-reeling coils are driven by a direct-current motor whose speed is controlled by a thyratron tube which lets more or less current pass to make the speed of the motor conform to the drawing speed of the wire. Ha (5.4)

Improvements in Cathode-Ray Tube Design. V. K. Zworykin. *Electronics*, Vol. 3, Nov. 1931, pages 188-190.

A new type of cathode-ray oscillograph is described of the hot-cathode, high vacuum type. The focussing of the spot is accomplished electrostatically by means of double anode structure. A special electrode is provided which gives undistorted control of the intensity of the spot, affording many new applications of the oscillograph, including its use as a television receiver. The voltages at which the oscillograph can be used vary from 500 to 15,000. The apparatus can be used for observation and recording of repeating phenomena, of continuous phenomena, and for the observation of transient phenomena. Twelve references are added. Ha (5.4)

Condensation
Bristol Company
Tagliabue Mfg. Co., C. J.
Damper
Bristol Company
Brown Instrument Co.
Foxboro Co.
Hays Corporation
Minneapolis Honeywell Co.
Morey & Jones, Ltd.
Tagliabue Mfg. Co., C. J.
Demand Pressure
Foxboro Company
Feed Water
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Filter Rate
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co. C. J
Flow
Brown Instrument Co.
Foxboro Co.
Republic Flow Meter Co.
Tagliabue Mfg. Co., C. J.
Gravity
Tagliabue Mfg. Co., C. J.
Humidity
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Humidity & Temperature
Bristol Company
Brown Instrument Co.
Foxboro Co.
Illinois Testing Labs.,Inc.
Minneapolis Honeywell Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Liquid Level
Bristol Company
Brown Instrument Co.
Foxboro Co.
Illinois Testing Labs., Inc.
Republic Flow Meter Co.
Tagliabue Mfg. Co., C. J.
Pressure & Vacuum
Bristol Company
Brown Instrument Co.
Foxboro Co.
Minneapolis-Honeywell Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Pyrometer
Bristol Company
Brown Instrument Co.
Foxboro Co.
Illinois Testing Labs., Inc.
Republic Flow Meter Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Rate-Volume
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Refrigeration
Bristol Company
Brown Instrument Co.
Minneapolis-Honeywell Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Special
Minneapolis-Honeywell Co.
Rubicon Co.
Tachometer
Bristol Company
Brown Instrument Co.
Foxboro Co.
Weston Elec. Inst. Corp.
Temperature-Time
Bristol Company
Brown Instrument Co.
Foxboro Co.
Illinois Testing Labs., Inc.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Thermometer
Bristol Company
Brown Instrument Co.
Foxboro Co.
Illinois Testing Labs., Inc.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Thermostat
Bristol Company
Brown Instrument Co.
Foxboro Co.
Minneapolis-Honeywell Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Thickness
Time
Bristol Company
Brown Instrument Co.
Foxboro Co.
Illinois Testing Labs., Inc.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Unit Heater
Minneapolis-Honeywell Co.
Vacuum
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Valve—Motor Operated
Bristol Company
Brown Instrument Co.
Foxboro Co.
Minneapolis-Honeywell Co.
Republic Flow Meter Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Water Level
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Republic Flow Meter Co.
Tagliabue Mfg. Co., C. J.
CONVERTERS
Bodine Electric Co.
COORDINATOGRAPHS
COUNTERS—Ratchet, Magnetic
Veeder-Root, Inc.
Revolution
Baldwin-Southwark Corp.
Bristol Company
Brown Instrument Co.
Veeder-Root, Inc.
Stroke
Baldwin-Southwark Corp.
Bristol Company
COUPLING TRANSFORMERS
General Radio Company
CREEP TESTER
Baldwin-Southwark Corp.
Alfred Suter
CURRENT RECORDERS
Bristol Company
Tagliabue Mfg. Co., C. J.
CURRENT REGULATORS
CYCLE COUNTERS
General Radio Co.
CYLINDERS-GRADUATED
Tagliabue Mfg. Co., C. J.
DAMPING TESTER
Baldwin-Southwark Corp.
DECELEROMETER
DEFORMETER (Beggs)
Baldwin-Southwark Corp.
DEMAND METERS
Gas
Foxboro Company
Republic Flow Meter Co.
Electric
General Electric Co.
DENSITOMETERS
DENSOMETERS
DIMMERS
Ward Leonard Elec. Co.
DIVIDING HEAD
Optical
Bausch & Lomb Optical Co.
DIVIDING MACHINES
R. Y. Ferner Co.
Gaertner Scientific Corp.
DRAFT GAGES—see Gages
DYNAMIC BALANCING EQUIPMENT
Alfred Suter
DYNAMOTORS
Bodine Electric Co.
EARTH CURRENT METERS
Rawson Elec. Inst. Co.
EBULLIOMETERS
Tagliabue Mfg. Co., C. J.
ELECTRIC TELEMETER
Baldwin-Southwark Corp.
ELECTRIC WAVE FILTER SECTIONS
General Radio Company
ELECTROMETERS
Rubicon Co.
ELECTRONIC METERS
Rawson Elec. Inst. Co.
EMPLOYEES' "IN AND OUT" TIME RECORDERS
ENGINE INDICATORS
Baldwin-Southwark Corp.
ENGINE REVOLUTION COUNTERS
Veeder-Root, Inc.
EXTENSOMETER
Baldwin-Southwark Corp.
Alfred Suter
FADE-OMETER
Atlas Electric Devices Co.
FATIGUE TESTERS
Atlas Electric Devices Co.
Baldwin-Southwark Corp.
Alfred Suter
FAULT FINDERS
General Radio Co.
Rubicon Company
Weston Elec. Inst. Corp.
FIELD RHEOSTATS
Ward Leonard Elec. Co.

A New Cathode-Ray Oscilloscope. W. O. Osgood. *Electric Journal*, Vol. 28, May 1931, pages 322-324.

A new simple, portable instrument permitting visual inspection of recurring phenomena on a linear time axis. The apparatus described permits the viewing of recurring phenomena, such as wave shapes of voltage or current on a fluorescent screen in an ordinarily light room. The apparatus is contained in a cabinet about the size of a suitcase. The new cathode-ray tube is of high vacuum, sealed-off type with an indirectly heated cathode, permitting the use of alternating current in the heater. The cathode is enclosed by a cylindrical control electrode in the end of which is a small hole exactly opposite the emitting surface. Directly in front of the central electrode, and coaxial with it, is another cylindrical electrode, called the first anode, closed at both ends and divided in the middle with a disc parallel to the ends. In the center of each end, and of the disc, is a small hole which is in line with the hole in the control electrode and the active cathode surface. The large size of the tube screen and the brilliancy of the wave makes the apparatus useful in large demonstration rooms, and in circuit development work where a knowledge of wave shape is valuable. The noises of machines may be studied with the oscilloscope where ordinary noise measuring instruments fail to give results. A bibliography is appended. WHB (5.5)

Exterior Photographs of Cathode-Ray Oscillographs with Low Exciter Voltage. (Aussenaufnahmen bei Kathodenoszillographen mit niedriger Erregerspannung.) H. Boekels. *Archiv Elektrotechnik*, Vol. 25, Feb. 21, 1931, pages 151-152.

For use of the oscillograph outside the laboratory an arrangement is used to avoid too high voltages; the described arrangement obtains with 17,000 volts, even at 3000 Hz, very clear outside photographs; the velocity of recording therefore was 0.3 km./ sec. In this connection it could be stated that the human eye is even more sensitive than the photographic plate, since for even lower frequencies and voltages which did not give any photographs, impressions on a phosphorescent screen could still be seen. Ha. (5.5)

Connections to Cathode-Ray Oscillograph for Photographing Periodic and Aperiodic Phenomena in Rectangular Coordinates. (Ueber Schaltanordnungen bei Kathodenstrahl-Oszillographen zur Aufnahme von periodisch and aperiodisch verlaufenden Vorgangen im rechtwinkligen Koordinatensystem.) W. Krug. *Elektrotechnik & Maschinenbau*, Vol. 49, March 29, 1931, pages 233-239.

A very exhaustive review of the arrangements which effect the deflection of the ray in the direction of abscissa and ordinate; of those arrangements which, in order to avoid overexposure in the zero position prevent the ray from acting on the photographic film before the exposure is made; of synchronization of the two movements, and of connections for any particular transient or irregular phenomenon. The latter can occur at both low and high voltages or for any length of time. 28 references supplement the article. Ha. (5.5)

A Contribution to the Development of the Cathode-Ray Oscillograph with Cold Cathode. (Ein Beitrag zur Entwicklung des Kathodenoszillographen mit kalter Kathode.) K. Beyerle. *Archiv Elektrotechnik*, Vol. 25, April 15, 1931, pages 267-276.

A modification of the normal instrument is described in detail which can be simultaneously seen by many and has a writing screen of 225 mm dia. The apparatus can be used with advantage for measurements in high-tension transmission systems and for recording purposes. Eleven references. Ha. (5.5)

Investigations on Helium X: On a Method of Measuring Minute Quantities of Radium. (Heliumuntersuchungen X. Ueber eine neue Methode zur Messung kleinster Radiummengen.) F. Paneth & W. Kolch. *Zeitschrift fur physikalische Chemie*, Bodenstein Festband, 1931, pages 145-161.

A method was worked out for the determination of radium emanation down to 10^{-13} Curie with an accuracy of 20%. The utilization for geological age determinations is set forth. EF (5.5)

Phase Measurements with the Cathode-Ray Oscillograph. L. A. Woon. *Review Scientific Instruments*, Vol. 2, Oct. 1931, pages 644-648.

The theory and formulas are developed by which phase differences can be determined directly from the geometrical dimensions of the ellipse which the oscillograph in connection with a low voltage tube records. The effects of harmonics in the curve to be oscillographed are discussed and method for obtaining good photographs explained. (Ha 5.5)

A Linear Time Axis for a Cathode-Ray Oscillograph. A. L. Samuel. *Bell Laboratories Record*, Vol. 9, Aug., 1931, pages 571-575.

A cathode-ray oscillograph tube can be conveniently used for obtaining stationary images of recurring phenomena at voice frequencies by adding a pair of condenser plates to supply the linear time axis for the amplitude-recording cathode ray. The electrical connections of such circuits which form the time axis and rapidly return the electron stream to the starting point after the completed period are described. Ha (5.5)

Grid Glow Micrometer. R. W. Carson. *American Machinist*, Vol. 75, Sept. 10, 1931, page 407.

For the measurement of ductile and plastic material with great accuracy, the contact between a needle point attached to the micrometer and the insulated ribbon was used to close a control circuit of a relay using a hot-cathode grid glow tube. This arrangement was sensitive to smaller measurements than could be read on the barrel of the micrometer. With a light ray on a screen readings of 1/1000 in. could be made. Ha (5.5)

FLASH & BURNING POINT TESTERS
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

FLOW METERS
Indicating
Morey & Jones, Ltd.
Indicating & Recording
Brown Instrument Co.
Foxboro Co.
Republic Flow Meter Co.
Tagliabue Mfg. Co., C. J.

FLUXMETERS
Rawson Electrical Instr. Co.

FOLDING TESTER

FRACTIONAL HORSEPOWER MOTORS
Bodine Electric Co.

FREEZING CABINET
Atlas Electric Devices Co.

FREQUENCY METERS
Indicating
General Electric Co.
Jewell Electrical Instrument Co.
Weston Elec. Inst. Corp.
Controlling
Recording
Bristol Company
Standards
General Radio Co.

FUEL ANALYSIS APPARATUS
Burgess-Parr Co.

FUEL FLOW INDICATOR
Morey & Jones, Ltd.
Republic Flow Meter Co.

FUEL GAS ANALYZERS
Hays Corporation

FURNACE CONTROLS
Bristol Company
Taylor Instrument Companies

FUSES
Instrument
Littelfuse Laboratories

GAGE RODS
Tagliabue Mfg. Co., C. J.

GAGE TESTING OUTFITS
Amthor Testing Inst. Co.

GAGES
Absolute Pressure
Bristol Company
Brown Instrument Co.
Foxboro Co.
Republic Flow Meter Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Amplifying
B. C. Ames Co.
Federal Products Corp.
R. Y. Ferner Co.
Comparator
B. C. Ames Co.
Federal Products Corp.
R. Y. Ferner Co.
Cylinder
B. C. Ames Co.
Federal Products Corp.
R. Y. Ferner Co.
Deformation
Baldwin-Southwark Corp.
Depth
B. C. Ames Co.
Federal Products Co.
Dial
B. C. Ames Co.
Federal Products Corp.
R. Y. Ferner Co.
Differential Pressure
Brown Instrument Co.
Foxboro Co.
Hays Corporation
Morey & Jones, Ltd.
Republic Flow Meter Co.
Tagliabue Mfg. Co., C. J.
Draft
Bristol Company
Brown Instrument Co.
Ellison Draft Gage Co.
Foxboro Co.
Hays Corporation
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Drill
Bausch & Lomb Optical Co.
Flow
Morey & Jones, Ltd.
Grinding
Federal Products Corp.
Liquid Level
Bristol Company
Brown Instrument Co.
Ellison Draft Gage Co.
Foxboro Co.
Illinois Testing Labs., Inc.
Morey & Jones, Ltd.
Republic Flow Meter Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Loss of Head
Bristol Company
Brown Instrument Co.
Foxboro Co.
Morey & Jones, Ltd.
Pitch Diameter
Federal Products Corp.
R. Y. Ferner Co.
Pocket
B. C. Ames Co.
Federal Products Corp.
Pressure
Bristol Company
Brown Instrument Co.
Foxboro Co.
Alfred Suter
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Pressure-Temperature
Bristol Company
Brown Instrument Co.
Foxboro Co.
Illinois Testing Labs., Inc.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Pressure & Vacuum
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Profile
Bausch & Lomb Optical Co.
Rain
Taylor Instrument Companies
Recording—Distance
Bristol Company
Brown Instrument Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Strain
Baldwin-Southwark Corp.
Alfred Suter
Tester
Baldwin-Southwark Corp.
Thickness
B. C. Ames Co.
Federal Products Corp.
R. Y. Ferner Co.
Vacuum
General Electric Co.
Volume
Brown Instrument Co.
Foxboro Co.
Water Level for Boilers
Bristol Company
Brown Instrument Co.
Foxboro Co.

PROTECT Those INSTRUMENTS!

Don't risk a valuable meter when overload protection costs so little. Littelfuses are made in 1/100, 1/32, 1/16, 1/8, 1/4, 3/8, 1/2, 3/4, 1 and 2 amps. capacity.

Also made in high voltage ranges, from 500 to 10,000 volts. Extremely quick in operation, accurate in calibration. A necessity in every laboratory. *Write for instructive catalog No. 4-E.*

LITTELFUSE LABORATORIES
1772 WILSON AVE. CHICAGO, U. S. A.

"Quicker than a Short circuit" **LITTELFUSES**

ACOUSTICS AND VIBRATIONS (6)

Sound and Vibration Phenomena and Measurements (6.1)

Measurement of Vibration. *Automobile Engineer*, Vol. 20, July 1930, page 238.

An apparatus based on wireless principles as an aid to testing engines, gear boxes, and any vibrating part. All audible vibrations are communicated to a microphone connected to a wireless amplifier. These reinforced anode currents are rectified and used to actuate a milliameter, the needle of which directly records the amplitude of the mechanical vibration. Provision is made for attaching the microphone to the part to be tested so that the effect of outside noises is reduced to a minimum. Other details of construction are given. [Ha 6.1]

Measuring Reverberation. Carl F. Eyring, *Bell Laboratories Record*, Vol. 9, March 1931, pages 315-319.

It is explained how the acoustical properties of a room are defined and measured. The life span of a sound wave, that is the period for which sound persists after emission has ceased, is controlled by the power output of the source, by the average distance between reflections, and by the fractional part of the energy absorbed on each reflection. This period is called reverberation time for a given initial intensity. Besides this factor the actual rate of decay of the sound is important. Both values are measured with a transmitter and oscillograph. Curves for different acoustic conditions are given. [Ha 6.1]

Study of Airplane and Instrument-Board Vibration. Stephen J. Zaic, *S. A. E. Journal*, Oct. 1931, pages 265-279.

A mathematical analysis was carried out in the investigation of resonance conditions between engine and engine mount. Then the problem was approached from a rather empirical viewpoint to give vibration relations, not, as heretofore, to bodily sensation, but to such terms as amplitude, frequency, the relation between the two, form, and the like. As no instruments are commercially available for recording these values under flight conditions, an apparatus of the same size as that of any standard aircraft instrument—a photographic recorder—was developed. It operates on the principle of the seismograph and embodies many interesting and novel features. A complete mathematical analysis, description and method of calibrating it is given. Vibration test-stands used for duplicating airplane vibration in the laboratory are also described. The analysis of records obtained on them seems to indicate that the duplication of vibration in the laboratory has not been fully accomplished. A total of 216 records from actual flight tests and from the laboratory tests was obtained. A limited number of records are reproduced, and the results from flight-test records are plotted in groups on four charts, which show that some airplanes vibrate excessively as compared with others and that, on some, the resonance points are within or very near the operating range. A table is presented which gives the arbitrary relation of bodily sensation to amplitude, and eight conclusions are stated which throw some light on the peculiar problem of vibration in airplanes. [6.1]

A New Meter for Noise Analysis. T. G. Castner, E. Ibrizi, G. T. Stanton & R. S. Tucker, *Electrical Engineering*, Vol. 50, May 1931, pages 342-343.

The Bell System has developed a sound meter which consists of a sound-pick-up device to convert acoustic into electrical energy, a multi-stage vacuum tube amplifier, a calibrated gain control to measure sound levels over a range of 90 decibels corresponding to a range of 1,000,000,000:1 in input powers. An electric network to weigh different frequencies in a manner similar to that in which they are weighted by the ear, a rectifier and visual indicating meter which responds in a manner similar to the ear, and means for over-all acoustic calibration. The sound meter is calibrated in terms of a 1000-cycle pressure of 0.001 dyne/cm.^{2} in a free progressive wave which pressure is called the "reference sound level." Sound levels measured are expressed in decibels above this reference point. For a 1000-cycle note, this reference level is somewhat above the minimum threshold of audibility of the average observer. The layout, calibration, and uses of the sound meter are discussed. [WHH 6.1]

Range Limits of the Torsiograph. (Vibrograph) (Messbereichgrenzen des Torsiographen (Vibrographen).) R. von Eppan-Ehrenhorst, *Die Messtechnik*, Vol. 7, April 1930, pages 89-93.

This instrument is used for measuring the torsional vibrations or the degree of irregularity of rotating shafts. A heavy mass is driven by the shaft and coupled to the latter by a spring. The relative motion between mass and shaft is recorded by a finger, and it is investigated how closely and within which limits the recording finger or lever follows the movements of the shaft. The theory is developed and it is found that for very high frequencies and large amplitudes the curve shows discontinuities and the lever will not follow exactly. [Ha 6.1]

A Sound-Measuring Device. (Ueber eine Schallmessvorrichtung.) M. Vox Ardenne, *Elektrotechnische und Maschinenau*, Vol. 49, Sept. 27, 1931, page 731.

The arrangement for the measurement of the acoustic qualities of loud-speakers, microphones, etc., consists of a calibrated sound generator which works according to the interference principle and supplies, by destroying the resonance of a high-frequency circuit, all sound frequencies between 100 and 10,000 Hz. All voltages required can be taken from the electric light supply. [Ha 6.1]

The Evaluation of Vibrograms. (Das Auswerten von Vibrogrammen.) J. Geiger, *Die Messtechnik*, Vol. 7, Oct. 1931, pages 261-267.

The paper explains and discusses the diagrams of vibrations taken with a vibrograph, errors which often are due to resonance phenomena, straight line and torsional vibrations, vibrograms of relative motions and the evaluation of the diagrams. From the diagram also the acceleration, and by multiplying the latter by the mass, the force can easily be calculated. [Ha 6.1]

Wind
Bristol Company
Brown Instrument Co.
Taylor Instrument Companies

GALVANOMETERS
Brown Instrument Co.
General Radio Co.
Illinois Testing Labs., Inc.
Jewell Electrical Instrument Co.
Rawson Elec. Inst. Co.
Rubicon Company
Weston Elec. Inst. Corp.

GAS ANALYTICAL METERS
Chemical
Hays Corporation
Tagliabue Mfg. Co., C. J.
Electrical
Brown Instrument Co.

GAS LEAK INDICATORS
Taylor Instrument Companies

GASOLINE METERS

GAS-METERS
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.

GASOMETERS

GEOPHYSICAL INSTRUMENTS

GOVERNORS
Laboratory Dry & Wet Gas
Pressure
Bristol Company
Brown Instrument Co.
Tagliabue Mfg. Co., C. J.
Pump
Tagliabue Mfg. Co., C. J.

GLASS BLOWERS' GOGGLES
Burgess-Parr Co.

GLASS STRAIN TESTERS

GREASE TESTING APPARATUS
Tagliabue Mfg. Co., C. J.

GROUND DETECTORS
Rubicon Company
Weston Elec. Inst. Corp.

GROUND-OHMER

GYPSUM TESTING INSTRUMENTS
Alfred Suter

HAND TALLEYS
Veeder-Root, Inc.

HARDNESS TESTERS
Baldwin-Southwark Corp.
Alfred Suter

HARMONIC ANALYZERS

HELIOSTATS
Gaertner Scientific Corp.

HIGH FREQUENCY APPARATUS
Rawson Elec. Inst. Co.
Rubicon Company
Weston Elec. Inst. Corp.

HIGH VOLTAGE
Fuses
Littelfuse Laboratories
Indicators
Jewell Elec. Inst. Corp.
Weston Elec. Inst. Corp.
Measuring Devices
General Electric Co.
Jewell Elec. Inst. Co.
Weston Elec. Inst. Corp.
Testing Devices
General Electric Co.

HUB ODOMETERS
Veeder-Root, Inc.

HUMIDITY CONTROLLERS
Bristol Company
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

HUMIDITY RECORDERS
Wet & Dry Bulb Thermometers
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

HYDROGEN ION METERS
Indicating
Rubicon Company
Controlling, Recording

HYDROMETERS
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

HYGROMETERS
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

ILLUMINOMETERS
Weston Elec. Inst. Corp.

IMPACT HARDNESS TESTER
Alfred Suter

IMPACT TESTING MACHINES
Alfred Suter
Alternating

INDICATORS—See Gages

INDUCTANCES
General Radio Co.
Rubicon Company

INSTRUMENT CALIBRATION AND REPAIRS
Jewell Electrical Instrument Co.
Rawson Elec. Inst. Co.
Rubicon Company
Weston Elec. Inst. Corp.

INSTRUMENT FUSES
Littelfuse Laboratories

INSTRUMENT OILS

INSTRUMENT TRANSFORMERS
General Electric Co.
Jewell Electrical Instrument Co.
Weston Elec. Inst. Corp.

INSULATION TESTING EQUIPMENT
General Electric Co.
Rubicon Company

INTEGRAPHS & INTEGRATORS

INTERFEROMETERS
Gaertner Scientific Corp.

INVERTED CONVERTERS
Bodine Electric Co.

JOB TIMING RECORDERS

KEYS AND SWITCHES
General Radio Co.
Rubicon Company

KEYSTROKE COUNTERS (for Typewriters, Billing & Bookkeeping Machines, etc.)
Veeder-Root, Inc.

KILNBOY
Foxboro Co.

KILOVOLT AMPERE METERS

KLYDONOGRAPHS

LABORATORY RHEOSTATS
Ward Leonard Elec. Co.

LABORATORY WASHING MACHINES
Atlas Electric Devices Co.

LACTOMETERS
Tagliabue Mfg. Co., C. J.
Taylor Instrument Cos.

LAUNDER-OMETER
Atlas Electric Devices Co.

LENGTH MEASURING MACHINES
R. Y. Ferner Co.
Gaertner Scientific Corp.

LEVELS
Centering
Bausch & Lomb Optical Co.
R. Y. Ferner Co.
Engineer's, Wye, Precision, Prism
R. Y. Ferner Co.
Taylor Instrument Companies

LIQUID METERS

LOCOMOTIVE INDICATORS
Baldwin-Southwark Corp.

LUSTER METERS

MACHINE OILS

MAGNETIC RELAYS
Ward Leonard Elec. Co.

MAGNETOMETERS
Rubicon Company

MANOMETERS
Brown Instrument Co.
Foxboro Co.
Hays Corporation
Morey & Jones, Ltd.
Alfred Suter

MASTER CLOCKS
Gaertner Scientific Corp.

MEGOHMMETERS
Illinois Testing Labs., Inc.
Jewell Elec. Inst. Co.
Rubicon Company

MEGOHM VOLTMETERS
Jewell Electrical Instrument Co.
Weston Elec. Inst. Corp.

MELTING POINT APPARATUS
Burgess Parr Co.
Tagliabue Mfg. Co., C. J.

METER PROVERS, Gas

METER TESTERS, Gas

MICROMETERS
R. Y. Ferner Co.
Gaertner Scientific Corp.

MICROAMMETERS
General Electric Co.
Jewell Electrical Instrument Co.
Rawson Electrical Instrument Co.
Weston Elec. Inst. Corp.

MICROFARADMETERS
General Radio Co.
Jewell Elec. Instrument Co.
Rubicon Company
Weston Elec. Inst. Corp.

MICRO PYROMETERS

MICROSCOPES
Brinell
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.
Alfred Suter
Measuring
R. Y. Ferner Co.
Metallographic
Bausch & Lomb Optical Co.
Petrographical
Bausch & Lomb Optical Co.
Toolmakers'
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.

MICROTOMES
Bausch & Lomb Optical Co.

MILLIAMMETERS
Bristol Company
General Electric Co.
General Radio Co.
Jewell Elec. Inst. Co.
Rawson Elec. Inst. Co.
Weston Elec. Inst. Corp.

MILLIVOLTMETERS
Bristol Company
Brown Instrument Co.
General Electric Co.
Illinois Testing Labs., Inc.
Jewell Elec. Inst. Co.
Rawson Electrical Inst. Co.
Taylor Inst. Companies
Weston Elec. Inst. Corp.

MOISTURE METERS
Tagliabue Mfg. Co., C. J.

MOTOR RADIATOR VALVES
Minneapolis-Honeywell Co.

MOTOR STARTERS
Ward Leonard Elec. Co.

MOTION RECORDERS
Mechanical
Bristol Company
Foxboro Co.
Baldwin-Southwark Corp.

MOTORS
Bodine Electric Co.

MOTOR GENERATOR SETS
Bodine Electric Co.

MULTIMETERS
Jewell Elec. Inst. Co.
Rawson Elec. Inst. Co.

MULTIPLE PEN RECORDER
Baldwin-Southwark Corp.
Foxboro Co.

MULTIPLIERS
Jewell Elec. Inst. Co.
Weston Elec. Inst. Corp.

NEON FILLED TUBES

NEPHELOMETERS

OHM METERS
General Radio Co.
Jewell Elec. Inst. Co.
Rawson Elec. Inst. Co.
Rubicon Company
Weston Elec. Inst. Corp.

OILS

OIL METERS

OIL TESTING APPARATUS
Atlas Elec. Devices Co.
General Electric Co.
Tagliabue Mfg. Co., C. J.
Taylor Inst. Companies

OPERATION RECORDERS
Electrical
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.

ORIFICE METERS
Indicating
Morey & Jones, Ltd.
Indicating & Recording
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.

ORSAT APPARATUS
Hays Corporation

OSCILLATORS
Weston Elec. Inst. Corp.

OSCILLOGRAPHS
General Electric Co.
General Radio Co.
Baldwin-Southwark Corp.

OXYGEN RECORDERS
Hays Corporation
Tagliabue Mfg. Co., C. J.

PAINT TESTING INSTRUMENTS
Atlas Electric Devices Co.

PANTOGRAPHS
Gaertner Scientific Corp.

PAPER TESTING INSTRUMENTS
Atlas Electric Devices Co.

PERFORMANCE METER

PERMEAMETERS
Rubicon Company

PAPER TESTING INSTRUMENTS

PERISCOPES
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.

PHASE INDICATOR

PHASE SEQUENCE INDICATOR

PHONOGRAPH TURNTABLES, Electric
Bodine Electric Co.

PHOTO-ELECTRIC COLOR ANALYZERS
General Electric Co.

PHOTO-ELECTRIC COLOR COMPARATORS
General Electric Co.

PHOTO-ELECTRIC CELLS
General Electric Co.
Weston Elec. Inst. Corp.

PHOTOMETERS
Gaertner Scientific Corp.
Bausch & Lomb Optical Co.

PHOTO-MICROGRAPHIC EQUIP.
Bausch & Lomb Optical Co.

PHYSICAL TESTING MACHINES
Atlas Elec. Devices Co.
Baldwin-Southwark Corp.
Alfred Suter

PITOT TUBE METER
Brown Instrument Co.
Foxboro Co.

PLANIMETERS
Automatic Flow Record
Brown Instrument Co.
Foxboro Company
Linear
Brown Inst. Co.
Baldwin-Southwark Corp.
Radial
Bristol Company
Foxboro Co.
Square Root
Foxboro Company

POLARISCOPES
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.

POSITION RECORDERS
Bristol Company
Foxboro Co.
Tagliabue Mfg. Co., C. J.

POTENTIOMETERS—Indicating
Brown Instrument Co.
General Electric Co.
Rubicon Company
Recording & Controlling
Brown Instrument Co.
Standard Cell Comparing
Eppley Laboratory, Inc.
Feussner Type
Eppley Laboratory, Inc.

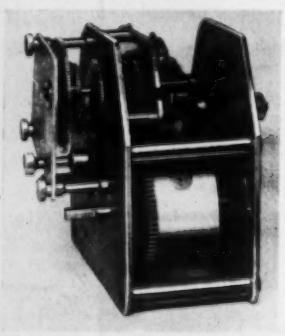
POWER FACTOR METERS
General Electric Co.
Jewell Elec. Inst. Co.
Weston Elec. Inst. Corp.

PRESSURE RECORDERS
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Cos.

PROCESS TIMING AND SIGNALING INSTRUMENTS
Bristol Company
Foxboro Co.
Tagliabue Mfg. Co., C. J.

PROJECTION LANTERNS
Bausch & Lomb Optical Co.

TIMING UNITS



Chelsea Power Movement used in Strip Chart Recorder.

Do you use a timing unit? Are you developing a new instrument or other device in which a clock movement is required? We have been building special clock movements for nearly fifty years and are sure we can help you in your development work. Correspondence invited.

CHELSEA CLOCK CO.
284 Everett Ave.
CHELSEA, MASS.

PROTRACTOR
Optical
Bausch & Lomb Optical Co.

PSYCHROMETER
Recording
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Inst. Companies
Sling
Taylor Inst. Companies

PYRHELIOMETERS—
Weather Bureau Type
Eppley Laboratory, Inc.

PYROMETERS
Optical
Pyrometer Instrument Co.
Radiation
Indicating
Brown Instrument Co.
Pyrometer Instrument Co.
Taylor Instrument Companies
Recording
Brown Instrument Co.
Pyrometer Instrument Co.
Taylor Instrument Companies
Thermo-electric
Immersion
Bristol Company
Brown Instrument Co.
Foxboro Co.
Pyrometer Instrument Co.
Taylor Instrument Companies
Indicating
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Companies
Recording and Controlling
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Companies
Surface Contact
Bristol Company
Brown Instrument Co.
Jewell Elec. Inst. Co.
Pyrometer Instrument Co.
Taylor Instrument Companies

RADIATION TUBES
Pyrometer Instrument Co.

RADIO FREQUENCY OSCILLATORS
General Radio Company
Jewell Elec. Inst. Co.

RADIO SET ANALYZERS
General Radio Company
Jewell Elec. Inst. Co.
Weston Elec. Inst. Corp.

RADIO TUBE CHECKERS
General Radio Company
Jewell Elec. Inst. Co.
Weston Elec. Inst. Corp.

RADIO TEST PANEL
Jewell Elec. Inst. Co.
Rubicon Company
Weston Elec. Inst. Corp.

REFRACTOMETERS
Bausch & Lomb Optical Co.

REGULATORS—See Controls

RELAYS
General Electric Co.
General Radio Co.
Jewell Elec. Inst. Co.
Minneapolis-Honeywell Co.
Ward Leonard Elec. Co.
Weston Elec. Inst. Corp.
Light Sensitive
Burgess Laboratories, Inc., C. F.
Vacuum Contact
Burgess Laboratories, Inc., C. F.
Vacuum Tube
Burgess Laboratories, Inc., C. F.

REMOTE METERING EQUIPMENT
Bristol Company
Brown Instrument Co.
General Electric Co.
Republic Flow Meter Co.

RESISTANCE—Electrical
General Radio Co.
Rubicon Company

RESISTOR UNITS
Ward Leonard Elec. Co.

"REV-METERS"
Veeder-Root, Inc.

RHEOSTATS
General Radio Company
Rubicon Company
Ward Leonard Elec. Co.

SACCHARIMETERS
Bausch & Lomb Optical Co.
Taylor Inst. Companies

SACCHAROMETERS
Tagliabue Mfg. Co., C. J.

SALINITY INDICATORS
Rubicon Company

SCALES
Gaertner Scientific Corp.
Alfred Suter

SEISMOGRAPHS
R. Y. Ferner Co.

SERVICE RECORDERS

SHUNT METERS
Bristol Co.

SHUNTS
Jewell Elec. Inst. Co.
Rawson Elec. Inst. Co.
Rubicon Company
Weston Elec. Inst. Corp.

SIGNALING DEVICES—Automatic
Brown Instrument Co.
Foxboro Co.
Republic Flow Meter Co.
Rubicon Company

SLOW SPEED MOTORS
Bodine Electric Co.
Minneapolis-Honeywell Co.

SPECIAL INSTRUMENTS
Burgess Laboratories, Inc., C. F.

SPECIAL ELECTRICAL INSTRUMENTS
Atlas Electric Devices Co.
Bristol Co.
Brown Instrument Co.
General Radio Co.
Illinois Testing Labs., Inc.
Jewell Electrical Inst. Co.
Rawson Elec. Inst. Co.
Rubicon Company
Weston Elec. Inst. Corp.

SPECIFIC GRAVITY APPARATUS—Gas
Hays Corporation

SPECTROGRAPHS
Bausch & Lomb Optical Co.
R. Y. Ferner Co.
Gaertner Scientific Corp.

SPECTROSCOPES
Bausch & Lomb Optical Co.
R. Y. Ferner Co.
Gaertner Scientific Corp.

SPECTROPHOTOMETERS
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.

SPEED COUNTERS
Veeder-Root, Inc.

SPEED INDICATORS
See Tachometers

SPEED RECORDERS
Bristol Company
Brown Instrument Co.

SPEED REGULATORS
Ward Leonard Elec. Co.

STANDARD CELLS
Eppley Laboratory, Inc.
Weston Elec. Inst. Corp.

STOP WATCHES
R. Y. Ferner Co.

STRAIN GAGES
Baldwin Southwark Corp.
Alfred Suter

SULPHUR DIOXIDE METERS
Hays Corporation
Tagliabue Mfg. Co., C. J.

SULPHUR DETERMINATION APPARATUS
Burgess Laboratories, Inc., C. F.
Tagliabue Mfg. Co., C. J.

SUNSHINE RECORDERS
Taylor Instrument Companies

SURGE INDICATORS AND RECORDERS
General Electric Co.

SYNCHRONIZING FORKS—Electrical
General Radio Co.

SYNCHRONOUS MOTORS
Bodine Electric Co.

TACHOGRAPH
Baldwin-Southwark Corp.

TACHOMETERS
Bristol Company
Brown Instrument Co.
Foxboro Co.
Veeder-Root, Inc.
Weston Elec. Inst. Corp.

TACHOSCOPES
Brown Instrument Co.

TELEMETER
Baldwin-Southwark Corp.

TELESCOPES
Bausch & Lomb Optical Co.
R. Y. Ferner Co.
Gaertner Scientific Corp.

TENSILE TESTERS FOR PAPER, WIRE, SHEETS, ETC.
Alfred Suter

TENSOMETER (Huggenberger)
Baldwin-Southwark Corp.

TESTING MACHINES
Fatigue
Baldwin-Southwark Corp.
Alfred Suter
Impact
Baldwin-Southwark Corp.
Alfred Suter
Hardness
Baldwin-Southwark Corp.
Alfred Suter
Portable—Hardness
Alfred Suter
Portable—Tensile—Compression
Baldwin-Southwark Corp.
Alfred Suter
Sheet Metal
Alfred Suter
Baldwin-Southwark Corp.
Torsion
Oil & Bearing
Baldwin-Southwark Corp.
Universal
Baldwin-Southwark Corp.
A. Suter

TEXTILE TESTING INSTRUMENTS
Atlas Electric Devices Co.
A. Suter

THERMIONIC RECTIFIERS
General Electric Co.

THERMO-JUNCTIONS (Electric)
General Radio Co.
Rawson Electrical Inst. Co.

THERMOPILE—Coblenta Type
Eppley Laboratory, Inc.

THERMOMETERS
Gas Filled
Bristol Company
Brown Instrument Co.
Foxboro Company
Republic Flow Meter Co.
Tagliabue Mfg. Co., C. J.
Taylor Inst. Companies
Mechanical
Brown Instrument Co.
Foxboro Co.
Minneapolis-Honeywell Co.
Republic Flow Meter Co.
Tagliabue Mfg. Co., C. J.
Mercurial
Bristol Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Resistance
Brown Instrument Co.
Foxboro Co.
Vapor-Tension
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Inst. Companies
Wet & Dry Bulb
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

THERMOSTATS
Bristol Company
Brown Instrument Co.
Foxboro Co.
Minneapolis-Honeywell Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

TIME INDICATORS
Baldwin-Southwark Corp.

TIME METERS
General Electric Co.

TIME OPERATION RECORDERS
Bristol Company
Foxboro Co.
Tagliabue Mfg. Co., C. J.

TIME RECORDERS
Bristol Company
Brown Instrument Co.
Gaertner Scientific Corp.
Foxboro Co.
Tagliabue Mfg. Co., C. J.

TIME SWITCHES
General Electric Co.

TIMERS
Minneapolis-Honeywell Co.
Rawson Elec. Inst. Co.
Rubicon Company

TORSIOGRAPH
Baldwin-Southwark Corp.

TORSION MACHINES
Alfred Suter

TRANSFORMATION POINT RECORDERS
Brown Instrument Co.

TRANSFORMERS (Instrument)
General Electric Co.
General Radio Co.
Jewell Elec. Inst. Co.
Weston Electrical Inst. Corp.

TRANSITS
Engineer's, Surveyors, Mine
Gaertner Scientific Corp.
Pocket
Taylor Instrument Companies

TUNING FORKS—Electrically Driven
General Radio Co.
Gaertner Scientific Corp.
Rubicon Company

TURBIDIMETERS
Burgess-Parr Co.

U-TUBE MANOMETERS
Hays Corporation
Morey & Jones, Ltd.
Republic Flow Meter Co.

VACUUM RECORDERS
Bristol Company
Brown Instrument Co.
Foxboro Co.
Republic Flow Meter Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Cos.

VACUUM TUBE BRIDGES
General Radio Company

VACUUM TUBE RELAYS
Burgess Laboratories, Inc., C. F.

VACUUM TUBE VOLTMETERS
Jewell Elec. Inst. Co.
Rawson Elec. Inst. Co.

VALVES
Automatic Shut Off
Bristol Company
Brown Instrument Co.
Foxboro Company
Minneapolis-Honeywell Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Cos.
Balanced
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Diaphragm
Bristol Company
Foxboro Company
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Electrically Operated
Bristol Company
Brown Instrument Co.
General Electric Co.
Minneapolis-Honeywell Co.
Republic Flow Meter Co.
Reducing
Tagliabue Mfg. Co., C. J.
Regulating
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Minneapolis-Honeywell Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Safety, Fuel Shut-off
Minneapolis-Honeywell Co.
Tagliabue Mfg. Co., C. J.

VENTURI METERS
Brown Instrument Co.
Foxboro Co.
Republic Flow Meter Co.

VIBROGRAPH
Baldwin-Southwark Corp.

VIBROSCOPE
Baldwin-Southwark Corp.

VISCOSIMETERS
Tagliabue Mfg. Co.
Taylor Inst. Companies

VOLTAGE DIVIDERS
General Radio Co.
Rubicon Company

VOLT-AMMETERS
General Electric Co.
Jewell Electrical Inst. Co.
Weston Elec. Inst. Corp.

VOLTMETERS
Electrostatic
Rawson Elec. Inst. Co.
Indicating
General Electric Co.
General Radio Co.
Jewell Electrical Inst. Co.
Rawson Electrical Inst. Co.
Weston Elec. Inst. Corp.
Recording
Bristol Company
General Electric Co.
Thermionic Rectifier
General Radio Co.
Jewell Elec. Inst. Co.

WATER METERS
Foxboro Co.
Republic Flow Meter Co.
Tagliabue Mfg. Co., C. J.

WATER & SEDIMENT APPARATUS
Tagliabue Mfg. Co., C. J.

WATTHOUR METERS
General Electric Co.

WATTMETERS
Indicating
General Electric Co.
Jewell Electrical Instrument Co.
Rawson Elec. Inst. Co.
Weston Elec. Inst. Corp.
Recording
Bristol Company
General Electric Co.

WAVEMETERS
General Radio Co.

WAX MELTING APPARATUS
Tagliabue Mfg. Co., C. J.

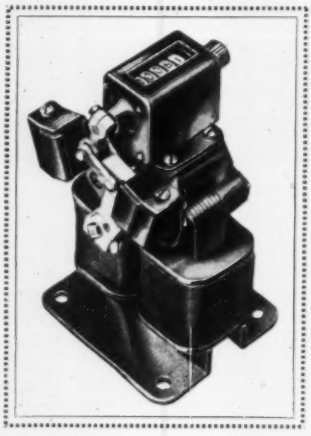
WEAR-OMETER
Atlas Electric Devices Co.

WEATHER-OMETER
Atlas Electric Devices Co.

MAGNETIC COUNTERS

Veeder-Root

offers Magnetic Counters as primary control-instruments in operating production machines. These Counters give you an every-minute record of production at individual machines. No waiting for reports from the factory. You get the total of finished products or smallest parts—*as fast as produced.* "Wired" to you from machines or assembly lines. Recorded on the Counter-dials over your desk.



Mechanical contacts on machines in the shop make and break the electrical circuits which operate the Counters over your desk, or banked on convenient counter-board. Your regular lighting circuit supplies the current (or storage batteries if so specified in ordering Counter). Let us give you complete information on application of these Counters to your machine needs. « «

Mechanical Counters for every requirement are shown and described in the Veeder-Root Catalogue. Write for copy, and ask for the facts on how Counters simplify profit-making at the types of machines you operate.

OFFICES IN THE PRINCIPAL CITIES

Veeder-Root INCORPORATED HARTFORD, CONN.

BUILDERS OF COUNTERS FOR EVERY PURPOSE

RAWSON MULTIMETERS

D C
13 RANGES
From 1 Microamp
to 1 Amp
and
20 Microvolts
to 1000 Volts

A C or D C
THERMAL
13 RANGES
From 2 Millamp
to 1 Amp
and
60 Millivolts
to 1000 Volts

Type 501A, B & C. Also Type 502 Thermal

FOR MEASUREMENT OF AC IN MICROAMPERES USE RAWSON ELECTRONIC METERS.

Rawson Electrical Instrument Co.

INCORPORATED 1918

CAMBRIDGE, MASS.

Branch Office:
91 Seventh Avenue
New York City

Mid-Western Representative:
EARL N. WEBBER
Daily News Bldg., Chicago, Ill.

Also Manufacturers of DC Multimeters, (AC or DC) Thermal Multimeters, Microammeters, Milliammeters and Ammeters, Microvoltmeters, Millivoltmeters, and Voltmeters, Cable Testers, Timers, Earth Current Meters, Fluxmeters, Thermo Junctions, Electrostatic Voltmeters, Wattmeters, etc.

Single Pivot Meters Supplied to Special Order
Special Apparatus Built to Order

Write for bulletins.

ADVERTISERS' INDEX

B
Baldwin-Southwark Corporation ..... A
Bristol Company ..... Back Cover
Brown Instrument Co. ..... A
Burgess Parr Company ..... A

C
Chelsea Clock Company ..... A

E
Ellison Draft Gage Co. ..... A
Eppley Laboratory ..... A

F
Federal Products Corp. ..... A
Ferner Co., R. Y. ..... A
Foxboro Co., Inc. ..... A

G
Gaertner Scientific Corp. ..... A
General Radio Co. ..... A

H
Hays Corporation ..... A
Heusser Instrument Mfg. Co. ..... A

L
Littelfuse Labs. ..... A

M
Morey & Jones, Ltd. ..... A

P
Pyrometer Instrument Co. ..... A

R
Racine Company, Jules ..... A
Rawson Electrical Instrument Co. ..... A
Review of Scientific Instruments ..... A
Rubicon Co. ..... A

T
Taylor Instrument Cos. ..... Inside Back Cover

V
Veeder-Root, Inc. ..... A

W
Ward Leonard Electric Co. ..... A
Weston Electrical Instrument Co. ..... A

An Indispensable Tool for Every Engineer and Industrial Executive

FUNDAMENTALS OF INSTRUMENTATION

By M. F. BEHAR

Never was the importance of measurement and control so keenly felt by industry as in these times. This book opens the door to countless ideas of incalculable value. It is not a mere collection of "kinks" but a basic text, every line of which should be read by industrial engineers and executives. The benefits of measurement and control never come of their own accord, but only when instruments are intelligently applied. This book takes you by the hand and leads you into the newest branch of engineering—the newest field of scientific management—Instrumentation. Not only does it crystallize and summarize the elements of the science of measurement and the art of control, but it lays down *for the first time* an impressive amount of new data never published before. The author has also induced other prominent instrumentation engineers to explain in detail "how they do it." Altogether, this is more than a book: it is a *tool!*

CONTENTS

Industrial Instruments—General
Properties and Characteristics of Industrial Measuring Instruments
Performance of Automatic Controllers
The Plant Instrument Department

MAIL THIS COUPON TODAY

Instruments Publishing Company Date.....
3619 Forbes Street, Pittsburgh, Pa.

Enter my order for a copy of "Fundamentals of Instrumentation" by M. F. Behar, at two dollars ($2.00) postpaid, to be invoiced only when shipment is made.

Name.....

Address.....

4000 NEW SUBSCRIBERS FOR INSTRUMENTS

On two or more new subscriptions or renewals sent together on one order before May 1

THE RATES WILL BE REDUCED AS FOLLOWS:

2 separate one-year subscriptions $2.40 — 4 separate one-year subscriptions $4.20
3 separate one-year subscriptions 3.30 — 5 separate one-year subscriptions 5.00

(The regular subscription price for INSTRUMENTS is Two Dollars a year)

Instruments Publishing Company
3619 Forbes Street, Pittsburgh, Pa.

Enter or renew subscriptions for the following and invoice them directly:

Name..... Address.....
Name..... Address.....
Name..... Address.....
Name..... Address.....
Name..... Address.....

Signed.....